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ERRATA SEPTEMBER RECORD.

VOLUME XXIII, No. 3, 1920.

Page 145. Insert footnote 4. Wakker, J. H. en Went. F. A. F. C.—De Ziekten van het suikerriet op Java. 1898.

Pages 166 and 168. Plate IX should be plate X, and plate X should be plate IX.

HAWAIIAN SUGAR PLANTERS' ASSOCIATION

THE HAWAIIAN PLANTERS' RECORD

Volume XXIII. JULY, 1920 Number 1

A monthly paper devoted to the sugar interests of Hawaii and issued by the Experiment Station for circulation among the Plantations of the Hawaiian Sugar Planters' Association.

Wireworms as Cane Pests in Hawaii.

By O. H. Swezey.

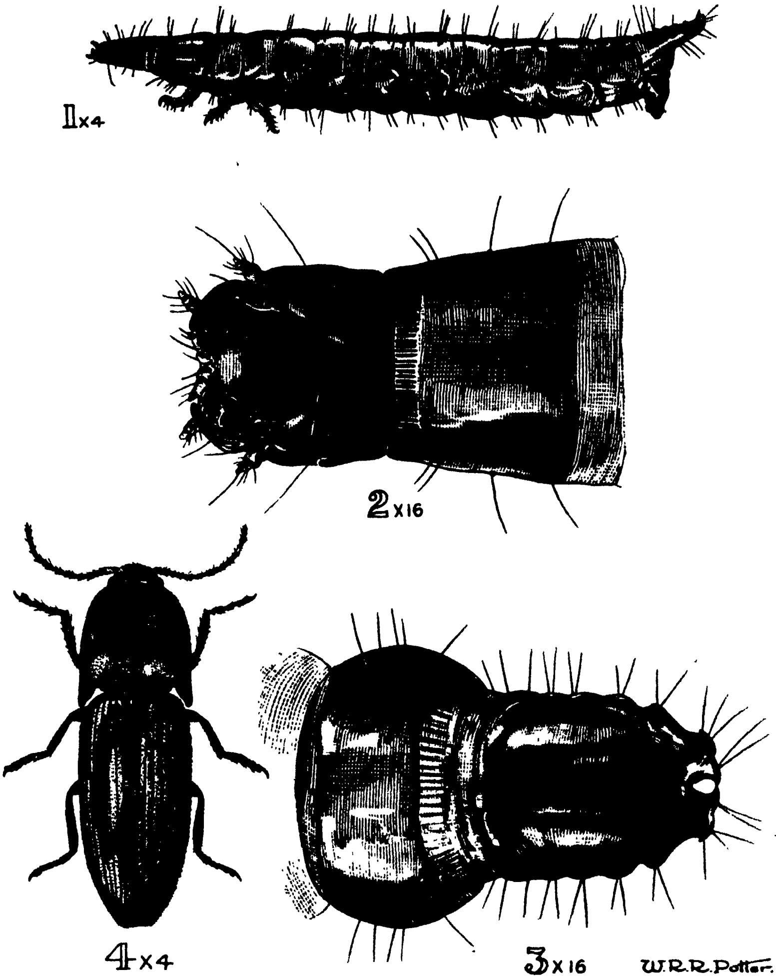
A recent investigation (April, 1920,) in the cane fields at Honokaa Sugar Co., demonstrates that wireworms may become serious cane pests under certain circumstances.

Wireworms are the more or less cylindrical larvae of the Elateridae, a family of beetles commonly called click-beetles, skip-jack and snapbugs. The particular species here concerned is *Monocrepidius exul* Sharp. It has long been known in the Hawaiian Islands, and is an immigrant insect first described from New Zealand, where it was also an immigrant, probably having come from Australia.

This insect first came to our attention as of economic importance as an enemy of the cane borer, its larvae being found to prey on the grubs and pupae of the borer. For an account of this see Planters' Record, III, pp. 7-9, 1910.

A few years later when the *Anomala* grubs were so abundant in certain fields of Honolulu Plantation and Oahu Sugar Co., wireworms of this species were also found among them and were considered of some value as a predator on the *Anomala* grubs. (See Planters' Record, XV, p. 345, 1916.) When kept in close confinement with grubs in soil, a wireworm was found to eat one or more of the grubs daily. As the wireworms have a long period of growth, one of them would account for the destruction of a large number of *Anomala* grubs in the course of its lifetime. There is no doubt but what it is also to some extent predatory on the grubs of the Japanese rose beetle, and many other insects, in fact perhaps taking whatever it can find in the soil suitable to its taste.

From the observations thus far made this insect was considered beneficial on account of the predacious habits of its larvae. The larvae also are of a different type of structure (see the accompanying figures) than the wireworms which have been known to be destructive to plants or the roots of plants. These latter wireworms are more cylindrical, and the posterior end of the abdomen more pointed. We have one such here, *Simodactylus cinnamomeus* (Boisd.),



MONOCREPIDIUS EXUL (WIREWORM).

Fig. 1—Full grown larva, side view. Fig. 2—Under surface of head. Fig. 3—Upper surface of terminal spoon-shaped segment. Fig. 4—Adult beetle.

a larger species than *M. exul*, but its larvae have not attracted particular attention by being abundant enough to produce noticeable injury.

In the investigation of reported injury by wireworms at Honokaa, they (*M. exul*) were found in fields of all kinds of conditions: in stubble where cane had recently been harvested; in fields of about half-grown cane; in fields being plowed; in fields being planted; and in fields that had been recently planted, i. e., one week to two months. These fields were situated in the upper part of the plantation, mostly above the government road and extending to the upper limits of the plantation.

The injury done by the wireworms is the burrowing into and eating of the eyes of seed cane before they have germinated, and also eating into and destroying the tender new shoots which have just started. One to several eyes may be

eaten out on the same seed piece; sometimes all of them are, the wireworms penetrating even beneath the leaf-sheaths, when present, to find the eyes. The destruction of so many eyes and young shoots makes it necessary for a great deal of replanting, later on, to obtain the desired stand of cane in the field. Where several hundred acres are involved, the expense of this replanting will amount to considerable.

In most of the fields examined, the larvae or grubs of the Olinda beetle (*Pantomorus fulleri*) were also found present, in about equal numbers to the wireworms. From our previous knowledge of the predacious habits of this wireworm, it is to be inferred that their presence in the cane fields at Honokaa is primarily as a predator on the grubs of the Olinda beetle. When these grubs are not available, or have all matured, or been consumed, the eyes and tender young shoots of the seed cane furnish attractive food for the wireworms. Where the greatest amount of injury was being done was in a field that had been planted about two months, and none of the grubs of the Olinda beetle were to be found. Either they had already all been eaten, or else had matured, for wherever these grubs were found they were nearly all full-grown, ready to pupate and complete their transformation to adults.

The wireworms also were largely full-grown, and about one-seventh as many pupae were found as larvae in the soil, and in some places a good many adult beetles were found. For about a week the beetles had been coming abundantly to lights in the evening at the manager's house. The indications were that there would soon be a considerable diminution of the wireworms in the fields on account of their maturing. Hence, it would be likely that later planted seed would not suffer injury from them. It should be well started before another brood of the wireworms would come on or be large enough to cause much injury. However, the life history, seasonal occurrence, etc., of these insects are not well known, and special study of them will be necessary to ascertain what bearing they may have on the time to plant cane to avoid wireworm injury. Further observations are also necessary to determine the relation of their occurrence to the presence of the Olinda beetle larvae, and as to the inter-relation of the life cycles of the two insects.

According to publication of investigations on wireworms in other countries, no successful method has been found for poisoning wireworms. Nevertheless, at Honokaa, some experiments have been started with poison and repellents, both in a small way and in the field. Tests are also being made of closer planting of seed in the row, so that even though a considerable number of the eyes should be destroyed by the wireworms, there yet would be a sufficient number left to produce the desired stand of cane, without having to replant later on.

Some fields of Paauhau Plantation were examined and conditions as regards wireworms and Olinda beetle grubs were found to be quite similar.

Both of these plantations have previously reported injury to seed by wireworms, but when visited by an entomologist at that time, not enough evidence could be found to determine definitely what insect was responsible for the injury. They had mostly matured or had disappeared for other cause.

Wireworm Injury to Seed Cane in Other Countries.

Mr. Edmund Jarvis, in Entomology Bulletin No. 3, of the Queensland Bureau of Sugar Experiment Stations, page 17, 1916, reports wireworms (*Monocrepidius* sp.) as injurious in some parts of Queensland. "In 1910 this pest inflicted serious damage to young cane recently planted on alluvial flats at Mackay; and in the same year occurred very freely in the Central Isis district, where it was reported to be causing more damage than any other insect."

Mr. Jarvis gives the following brief extract from a letter by Mr. H. R. Hart, of Mackay, in September, 1915, which serves to illustrate the nature of injuries due to wireworm there: "The worm attacks the eyes of the 'sets' immediately after planting, apparently feeding on the soft content of the eye, and then passing on to the next 'set,' continuing sometimes from end to end of the field. I have known several cases where fields of cane have had to be plowed out and replanted from this cause; and in my own experience I once planted a small field of about two acres three times with the same result."

Mr. Jarvis adds: "Apparently the ravages of this pest are of very local occurrence."

It is possible that the wireworm of Queensland (*Monocrepidius* sp.), mentioned by Jarvis above, is the same as the one we have here (*Monocrepidius exul*).

In Agricultural Report No. 1 (1916), of the Colonial Sugar Refining Co., Mr. Robert Veitch discusses injury to sugar cane "sets" by wireworms in Fiji. There the wireworm is the larva of a different species (*Simodactylus cinnamomeus* (Boisd.). This is a species we have in the Hawaiian Islands, but does not seem to become numerous enough for injury. Only an occasional specimen was found in the Honokaa fields.

According to Mr. Veitch, the greatest injury is done in rich, alluvial flats, where the loss is commonly 40%, and goes as high as 75%, and even 80% has been observed.

The most promising remedial measure proposed there is: "When fields are known to be liable to wireworm injury it is advisable to make provision for failures. This is best done by the continuous planting of a certain portion of the rows. If every fifth row is so planted there is provision for a twenty per cent failure, when the spacing in ordinary rows is fifteen inches from end to end of fifteen-inch sets. When required, the surplus plants should be dug out of the continuous rows and used to fill the blanks in the ordinary rows. This operation should be carried out only when there is promise of rain, always bearing in mind that the earlier it is done the more even will be the stand of cane. New 'sets' should not be used to fill blanks in badly infested fields, as they are at once attacked by wireworms and many of them destroyed. If no rows have been planted continuously to provide for losses it is advisable to dig up a number of ordinary rows at the edge of the field and use their sets to fill the blanks in the other rows. The rows that have been dug out can then be planted as a new block."

Experiments With Sodium Cyanide Against Wireworms in Corn in New Jersey.

Dr. Alvah Peterson, at the New Jersey Agricultural College Experiment

Station, has found that wireworms can be killed by the application of a solution of sodium cyanide, but that it is a very expensive procedure, and requires the solution to be applied at the rate of more than 150 pounds per acre. The most satisfactory results of these experiments are given as follows,[1] showing that they had to resort to crop rotation to meet the problem of wireworm control:

"As a last attempt to kill wireworms with sodium cyanide a number of hills of corn, heavily infested with larvae and in an untreated section of the field, were uncovered with a hoe on June 5 and about one quart of water, in which sodium cyanide was dissolved at the rate of 300 pounds per acre, was poured upon the larvae within each hill and then immediately covered with soil. The same treatment plus an equal amount of ammonium sulfate was also tried on a number of infested corn hills. These hills were examined on June 11 and all the larvae found dead, 15 to 40 to the hill. This drastic method of treating hills is apparently very effective, yet even in this treatment some of the larvae may have been repelled by the sodium cyanide which we do not know of. The results of this experiment show that it is possible to kill wireworms if one uses large doses of cyanide and applies the material directly upon the larvae.

"In conclusion it can be said that wireworms can be killed with large quantities of sodium cyanide, but the amount necessary to bring about a satisfactory control makes this method of soil treatment too expensive for ordinary use in the field.

"Since we were unable to control wireworms satisfactorily with sodium cyanide at the Orange City Poor Farm, a system of crop rotation designed to meet the problem of wireworm control was worked out by Dr. Headlee and Mr. Quinn, which will be put into operation during the coming season."

A Popular Description of Cane Sugar Refining.*

By H. C. Welle.[2]

No doubt most cane sugar manufacturers and beet sugar producers think of the business of sugar refining much as I formerly did,—namely, that sugar is sugar, that refinement into the white product is only a simple step further from its extraction from the sugar-producing plant, and that the real essential in the whole process from extraction to the breakfast table is that part that leaches from the plant its burden of sweetness and puts it into a crystallizable condition. Having been one of the host of beet-sugar workers of the Western States for many years, with a somewhat detailed knowledge of the troubles and development that that industry had gone through to its present high state of technical perfection, my belief was firm that the procedure of the refinement of raw cane sugar,—clean, uniform, fragrant, 96% pure, crystallized cane sugar,—must indeed be child's play, almost beneath the dignity of beet-sugar pioneers!

[1] 38th Annual Report New Jersey State Agricultural Experiment Station, 1917, p. 479.
* Presented at a special meeting of the Hawaiian Chemists' Association, April 17, 1920.
[2] Chief Chemist, California and Hawaiian Sugar Refining Company, Crockett, California.

We all have our blasted visions some time in a lifetime, and I must confess that one of mine flashed before my eyes a short time after my initiation into the sugar refining business. For, what I found there, gentlemen, was not the picture of simplicity that I had imagined. I found it could not be designated truthfully with the scornful term of "laundry," as christened by the Louisianans; but instead, I began to realize that it was a wonderful, involved, complex work, that staggered one with its magnitude of quantities, difficulties, exactions, capital at stake, and possibilities of development.

The art of cane sugar refining is a web of complications, so finely drawn that they are never heard of by the layman and seldom by the raw sugar producer. Before giving you a brief description of the consecutive steps of the refining operation, I shall dwell upon just two of these details as illustrative of my meaning.

Glucose, to a beet-sugar producer, is an unknown substance in his operations, and therefore an ignored and uninteresting one. You cane sugar manufacturers are wiser than that, and no doubt have your joys and griefs with this sugar. But I wonder if you realize its importance to the refiner, at least to a refiner of an alkaline house, where its slightest disintegration in an alkaline medium means a darkening of the immaculate liquors required for the high-grade product demanded by a more and more exacting public; or, whose decomposition (and consequent acidifying of the alkaline liquors) invites a further addition, to prevent inversion, of more lime—lime, a mineral ash, a directly added impurity, every bit of excess of which means an increase of non-sugars entering into the immobilization of crystallizable sucrose. Glucose is the great essential for the production of the beautiful golden soft sugars of commerce, but its slightest abuse gives a dirty-looking, red, unmarketable product instead.

This is just one of the many snares that foul the refiner's path, and I mention briefly the complication of the presence of glucose because it is a subject that you are well familiar with yourselves. And further, I venture to say that many of your troubles of manufacture are also ours to a modified or exaggerated degree. For, although the great variations between ripe cane and green cane, or sound beets and decayed beets, are not experienced in our raw product, the slighter variations of raw sugar as our raw product subject us to the same difficulties. Sugar producers' or refiners' troubles originate, not from the sucrose, but from the non-sucrose, and as refineries are built for the handling of raws of normal non-sugar content, any deviation therefrom, although measured in small percentage, affects operations just as much and just as aggravatingly and expensively as the wider variations experienced by the producer of sugar from the plant itself.

You have all heard, time and again, of the damaging influence of ash and sulphates in refining operations—I should say, that you have really only heard whisperings about these obnoxious ingredients of raw sugar, for to really be able to understand the viciousness of the trouble resulting therefrom, you must actually be in the midst of the refinery battle against this enemy. But, as you have heard the subject spoken of off and on before, I shall dwell on it no longer, but shall mention only one more difficulty before proceeding to a brief description of the process of refining. The difficulty of which I now speak will prob-

ably be of more interest than the subject of ash and sulphates, because lack of understanding has very largely kept the subject out of print. Serious though it is,—more serious than is generally recognized, because, first, numerous refinery troubles are due directly to this, but not realized; second, if realized, are not run to ground. I refer to iron—something that has no interest to the raw sugar producer, but is of the most vital interest to the refiner.

Every schoolboy entering the sugar business reads in any sugar text book that he picks up that iron in liquors makes gray sugars, and then forgets all about it, because, without explanation as to where it comes from, what form it is in, how to remove it or keep it out, or how it injures sugar, it naturally seems more like a superstition or guess than a truth. However, it is far from being a superstition—it is, rather, a very aggravating truth that becomes very vivid in refining operations whenever it appears. The difficulty in dealing with the matter lies in the fact that the iron, which enters the refinery in the raw sugar itself, is not in the familiar precipitable form which is so often encountered in minerals. On the contrary, it is organically combined to form a soluble salt which is not decomposed and precipitated by any of the ordinary precipitants of iron. Ordinarily, the iron will indicate its presence in the liquors by their darkening rapidly after char-filtration. The most serious immediate result is rapid darkening of the soft yellow sugars, which, although having the proper shade of color when manufactured, often are greatly changed in appearance by the time they reach the trade. Barrel syrup is affected in the same way.

As the art of refining is now practiced at Crockett as well as in the East, we find in actual operation with Hawaiian sugars that the intensive char-filtration first seems to disintegrate the iron organate, with the result that the organic radical is absorbed and held by the char while the iron is liberated and remains suspended in the liquor in a semi-collodial condition. The great amount of sulphates in the Hawaiian sugars are found to very quickly (within one month) saturate the char up to its selective capacity for sulphates, and these, in turn, break down (under the influence of heat during the char regeneration period) into a relatively large sulphide content. The result, chemically, is obvious—the semi-colloidal iron in the liquors, coming in contact with excess sulphides of the bone-char, results in semi-colloidal black sulphide of iron which contaminates the best liquors in the plant by making them very smoky in appearance, giving the white massecuite a black cast, degrading the granulated sugars, and, worst of all, positively ruining the yellow soft sugars.

Of course, the actual percentage of the objectionable iron is extremely small, but those of you familiar with the colloidal sulphide of iron know that a very little goes an extremely long ways. It only serves to illustrate the difficult factors involved in refinery work. In this instance, in order to carry the work to ultimate refinement, the extremely small amount of iron had, of course, to be removed. Although a new problem to us, it is gratifying to be able to say that we managed to do this in a comparatively short time and we anticipate no more trouble from this source.

Having gone to some length in mentioning the nature of the careful refinements necessary for successful work, you may be interested in now hearing just what the procedure of the refinery is.

First, however, let us consider the question: What is *refined* sugar?

Refined sugar, as we know it, is the result of the developed esthetic taste of people of the present age, and as long as humanity continues to develop that way, the refining of sugar will continue to live, and must continue to develop. People persist in wanting the best, the purest, the most beautiful, whether it be on their bodies, before their eyes, or in their stomachs. Refined sugar comes from the raw, impure, crystalline sucrose product, which has been melted, has had the maximum quantity of impurities removed by filtration, decolorization with bone-char (which is still considered the most efficient medium for the purpose), and re-crystallization into pure white sucrose crystals of, practically, 100% purity. What other food product is there that has such a degree of refinement?

Refined sugar, as the term is usually understood, is distinguished from white beet sugar or white plantation cane-sugar in that the latter two are produced from the raw liquors directly extracted from the beet or cane, with a *partial* process of purification, without, however, having the maximum amount of obnoxious coloring matter and odor removed as is the case in the refining of raw sugar by means of bone-char.

Sugar refining is, as most other industries, a gradual development to meet the demands for a finer product. Although it seemed to reach a stage of self-content which was maintained for many years, it undoubtedly is again beginning to make strides ahead in all parts of the country, and, we believe, particularly in the West.

You all know how we receive the raw sugar—in burlap bags approximately 125 lbs. net in weight, some soft and some exasperatingly hard, much good sugar and some not so good. All of it is trucked over scales presided over by one representative for the planters and one for the refinery. Each truck holds five sacks, and a sample from each fifth sack is composited in covered sample cans corresponding to the mark sampled, the samples being taken by a tryer to the middle of the sack. When the ship is unloaded, these cans are taken to the sample room, where the samples are thoroughly mixed by the representatives of both parties and divided into four parts, one going to the refinery laboratory for analysis, one to the laboratory of the A. A. Brown Co. in San Francisco for analysis, a third being held for referee analysis if necessary, and the fourth going to the refinery laboratory for the physical tests, such as we have been sending to the Islands for the past couple of years. To insure accuracy, all tests are made in duplicate, the instruments of precision always being tested by means of government certified standards before each lot of tests. The actual weighing of the raws received is controlled, checked and reported through a system of great detail under the control of a special department of weights and measures, the fundamental basis of which is the use of weights standardized and certified by the government. The bags of raw sugar are carried into the refinery on endless conveyors and belts, to the cut-in station, where they are discharged onto a long receiving table. Laborers here open the bags and dump the contents through a grating into the raw sugar bin, holding, when full 1500 tons, or approximately one day's run with our present equipment. The magnitude of this work alone will be more vividly realized by understanding that this means 24,000 bags every 16 hours (this work being confined to two shifts), or 25 bags per minute. Ob-

viously, under these conditions, caked raw sugars hamper the work of this station greatly. Ordinarily, the cargoes are stored temporarily in the warehouse, from which a number of different marks are fed into the refinery at the same time. If one of these marks should be badly caked, the cut-in station will, of course, have its difficulties, but the operation of the plant as a whole may continue in a normal manner by sending in a greater proportion of the softer sugars. In a time of slow shipments, however, such as the present season, most of the sugar must, necessarily, be sent directly from the ship to the cut-in station. If, then, a preponderating mark of the vessel is badly caked, the conditions at the cut-in station become so very severe that the capacity of the plant is greatly reduced unless a large excess of labor is employed and a necessary disregard is observed towards saving the empty bags in an undamaged condition. Very large shipments have been received in such a condition this year that the conveying apparatus has been injured, and heavy mauls have been required not only to break the sugar sufficiently to remove it from the bags, but also to force it through the grating of the sugar bins.

The empty bags are now sent to the bag laundry, where the adhering sugar (approximately 4 tons per day) is saved in the form of sweet-water. The raw sugar is removed from the bottom of the bin, elevated to the ninth, or top, floor of the melt house, and is there continuously discharged into two minglers.

The refining operations begin at this point, for as the golden stream of raw sugar pours down the chute from the top of the elevators, it falls directly into its first bath. The cleansing begins by the sugar being mixed, in what is termed the mingler, with a mixture of water and wash syrup, the latter resulting from this same procedure earlier in the day. This mixture with water and cold wash syrup (technically termed "affination syrup") results in a magma of 90° Brix cold. The latter is discharged into a mixer on the floor below, from which it is drawn into centrifugal machines. The object of this procedure is two-fold: first, to provide suitable means for washing the raw sugar, and, second, to soften the enveloping molasses of the raw sugar to a sufficient degree to facilitate its removal.

Twenty-two direct connected, electrically driven Watson-Laidlaw 48″ centrifugal machines (the last word in this type of machinery for the purpose) are employed for the purging of the affination magma, and it is expected that these machines will handle 2200 tons of raw sugar per day. The machines are open at the bottom, and are self-dumping, the discharge being 710 pounds of washed sugar. They are loaded five seconds after starting, while running at a speed of 250 R. P. M. In 25 seconds the machine is completely loaded and running at a speed of 650 R. P. M. During the next 45 seconds the machine has acquired its full speed of 870 R. P. M., and an average of 34 pounds of water in the form of an evenly distributed spray is then applied as a wash during the next 75 to 90 seconds. Spinning is continued for 30 seconds, at which time the power is shut off and the machine stopped in two minutes, the charge of washed sugar dropping out a moment before the machine comes to a complete stop. The self-dumping feature depends entirely upon the gravity of the sugar itself and upon the fact that the diameter of the basket is ½ inch larger at the bottom than at the top. The result of this entire procedure of mingling and washing is to pro-

duce, by separation, a washed sugar of at least 99.0° apparent purity and an affination syrup of 80° apparent purity, from an original raw sugar of approximately 97° apparent purity. As before stated, the run-off from these centrifugals (affination syrup) is partly returned to the minglers to enter into the raw sugar magma. The balance of the syrup is sent to the char house for a special treatment which will be described later.

The thoroughly washed light-yellow sugar now passes into a large storage bin with a long trough at the bottom running the length of the bin, in which it is mixed with hot sweet-water from another part of the plant. As it is mixed, it is conveyed to a discharging point where it runs into the melts on the floor below for completion of solution.

Contrary to expectations, after viewing the rather pleasing light-colored washed sugar, the washed sugar liquor of 62° Brix (at 80° C.) proves to be a brownish, dirty-looking liquid, colored and made turbid from the coloring matter in the crystals themselves and from the fiber and cush-cush hidden in between the individual crystals. Differences in the coloring content of various raw sugars is very apparent at this point, as would be expected when consideration is given to the fact that the crystals of certain Hawaiian raw sugars of equal polarization and purity contain from two to three times as much coloring matter as others. This is a very important matter to the refiner, for it means simply that the burden of the char to keep the production of white granulated sugars up to maximum with one char filtration is two to three times greater with certain sugars than with others of better grade.

The washed-sugar liquor, having been limed continuously to a phenolpthalein alkalinity of 0.003 to 0.004 as it passes through the melters, is pumped to the ninth, or top, floor of the char house. Here it goes to the blow-up tanks, through which it passes as a continuous operation, getting its addition of kieselguhr at this point, its allotment of No. 1 remelt sugar liquor from the pan floor, such steam as is required to maintain a temperature of 80° C., and sweet-water for final adjustment to the standard density.

The use of kieselguhr to aid filtration is not new in beet sugar house practice, but it has been extensively introduced into refinery work only during the last five years, and is the natural accompaniment of *pressure* cloth filtration. With the old system of bag-filtration (still largely in vogue in Eastern refineries) the advantage of the use of kieselguhr was rather negative. With the introduction of pressure filtration of refinery liquors, however, entirely with the Sweetland filter, the use of some such filtering medium as kieselguhr became an imperative matter to insure its success. In fact, it can be safely stated that, as far as our present knowledge goes, clear cloth filtration of high density raw liquors through pressure filters could not be accomplished in an economical way without the use of kieselguhr or some other such material yet to be discovered.

As the use of kieselguhr is, I think, a subject foreign to Island practice, a little description of it may be apropos. Kieselguhr is a diatomaceous earth,—that is, it is the deposit of myriads of microscopic skeletons of sea organisms of previous geologic periods. In Santa Barbara County of California it is mined in large blocks, brilliantly white, and is then worked down to a very light, fluffy

powder, capable of passing about 200 mesh. Microscopical examination will display many forms of the skeletons, all beautiful in design, but only the round, porous type are supposed to possess the characteristics required in sugar-house work. Chemically it consists of silica, between 80% and 85%, with calcium carbonate, aluminum and iron oxides, and organic matter as impurities. The diatoms are very porous, and for some reason, not clearly understood, they have a remarkable power of facilitating cloth-filtration of otherwise very difficultly filterable, gummy solutions.

The washed-sugar liquor, now having been prepared with lime, kieselguhr, and heat, is picked up by centrifugal pumps as it leaves the blow-up tanks, and is sent through the Sweetland presses at a pressure rising gradually from 10 lbs. to 60 lbs. The muddy brown washed-sugar liquor now appears again before us, as it runs from the presses in the form of a beautiful, sparkling, amber liquor of 62 Brix, for the first time really appetizing in appearance. Fourteen of these presses are used for the filtration of the washed-sugar liquor, each one capable of filtering the liquor of from 100 to 130 tons of raws per 24 hours. Interior sluicing is utilized in cleansing the cloths of accumulated mud, this procedure being necessary approximately every hour. Although accompanied by many discouragements during the introduction of these presses in our refinery, sufficient time has now elapsed to have clearly demonstrated that the use of Sweetland presses is the greatest step in advance in the filtration of refinery products in many decades. An enormous saving in labor, effective maintenance of densities, immaculate cleanliness, and, above all, positive assurance of sparklingly clear liquors at all times, have confirmed to everyone's satisfaction the wisdom that prompted the installation.

The filtered liquor is now ready for the treatment that makes a refinery most distinctive in its operations from a beet-white or plantation-white sugar plant. I refer to the bone-char filtration which the liquor enters upon soon after leaving the Sweetland presses.

For the sake of the uninitiated—bone-char is made by heating the hardest bones in kilns out of contact with the air. The organic matter which is part of bones is thus charred to a black carbon. After breaking up into the required grist, washed, etc., it contains about 10% carbon, the bulk of the remainder consisting of the main mineral constituent of bones, calcium phosphate. In other words, we have now for use in the refinery, a black, hard, very porous material, of the size of fine gravel, consisting of a skeleton of phosphate of calcium, covered, in its most microscopic portion, with animal carbon. This char has, together with many newly discovered vegetable carbons (one of the most perfect of which your own Mr. S. S. Peck is the inventor of), the remarkable property of absorbing the coloring matter of sugar liquors into its pores and retaining it there most tenaciously.

This property of bone-char is taken advantage of by the refiner for removing the coloring matter of the raw sugar liquor, which, if not accomplished, would make the manufacture of white cane sugar much more difficult and of a very unsatisfactory nature for the trade.

The bones utililzed for this purpose come from all over the world. A great deal of char in this country is manufactured from the bones collected in the

great slaughter houses of the middle West, but because of their having been through a boiling process they are inclined to produce a char somewhat low in crushing strength. Our experience would tend to indicate that the best bones for the purpose received on the Pacific Coast are those gathered on the great stretches of cattle lands of India.

The char-filtration of refinery liquors and syrups, with the associated activities of the pan floors, is such a very complex subject that it can hardly be touched upon in a paper of this scope. I think it will be necessary, therefore, to confine myself to a brief enumeration of the liquors and syrups put on to the char, those leaving the char, the pans boiled, the appearance of these products, and a description of the final output. The details of rates of flow, routine of filtration, rendement of liquors, elimination of ash and organic matter and re-filtration, can hardly be described at this time.

It must suffice, then, to state that the char house is divided into three parts, graded according to the quality of the char, No. 1 char being the oldest and therefore the poorest, No. 2 char being of medium quality, and No. 3 char being the best quality. The No. 1, or oldest, char is used solely for the first filtration of the Sweetland filtered affination syrup (which, it will be remembered, resulted from washing the raw sugar in the Watson-Laidlaw centrifugal machines). This syrup has passed through the blow-up tanks and Sweetland presses (10 in number) in the same way as washed sugar liquor, but, because it contained most of the impurities of the original raw sugar, is a muddy, very dark syrup until it has passed through the Sweetland presses. It appears then at the char filters as a beautiful, sparkling liquor, of the color of dark port wine.

The affination syrup, then, passes first over the No. 1 char, is re-filtered over the No. 2 char, and receives another char-filtration over the No. 3 char. In practice, it works out that this syrup receives about 3½ char filtrations, the final result being an amber-colored liquor of about 90° purity (an increase of 10 points from the original affination syrup), suitable for one pan of white granulated sugar, the syrup from the latter being used principally as the base for Golden C soft sugar.

The No. 2 char is used for the filtration of all the washed-sugar liquor, part of the granulated syrups from the white pans, and for the second filtration of the affination syrup. All of the char-filtered washed-sugar liquor produces white sugar; a considerable portion, being nearly water-white, is used for the production of cube sugar and the confectioner's large crystals.

The No. 3 char, having the finest cutting edge, is used for making the darkened granulated syrups and remelt sugars suitable for re-boiling into specialties and granulated, and also for giving the final refinement to the affination syrup, so that it, also, will be suitable for white granulated.

To summarize—the total number of products going on to char is 13, and the total number of grades leaving is 11. Of the latter, 7 grades go to the pan floor, the other 4 being returned to the char for re-filtration. Of the 7 grades of liquors going to the pans, 6 enter into the production of white sugars and one is used as a base for soft sugars.

The char-filters are run on liquors for a period of approximately 30 hours,

the balance of the 73-hour cycle being taken up with sweetening off, washing of char, draining and blowing down with air, emptying, and filling with fresh char.

The liquor gallery is largely the control point of the char house. It is here where the char-filtered liquors are closely watched, and it may be said that if inspection shows an abnormal condition of the char-filtered liquor for any length of time, it can be taken for granted that practically the entire balance of the refinery will encounter some difficulty later. The grading of the liquors, as they leave the char, according to purity and color, is conducted here, they being deflected into one or other of the various troughs according to what use is to be made of them.

When the allotted amount of liquor has passed through the char-filter, it becomes necessary to sweeten-off the filter with hot water, the sweet-water being conducted to the evaporators on the second floor of the refinery for concentration to a thick syrup. The sweetening-off process is continued until purity tests made in the liquor gallery indicate molasses purity. The washing is then continued to waste until all remaining sugar and most of the mineral salts absorbed by the char have been washed out. The sugar remaining in this discarded water is such a small quantity and is of such a low purity, because of the mixture with the washed-out impurities of the char, that it would be detrimental rather than beneficial to try to save it.

Before following the liquors any further from the liquor gallery, it will be well to tell you what strenuous treatment the char goes through before being ready for another period of hard work. Notwithstanding that it has received a most thorough hot-water bath, so complete as to remove most of the mineral salts and organic matter absorbed from the liquors, it has with great persistence refused to give up certain other organic matter, such as the gums that have passed along with the sugar from the day it was first expressed from the sugar-cane. These gums, in fact, may be said to have "gummed up the game" very completely by smearing themselves into the microscopic pores of the char during the filtration of the liquors, and clogging them so effectually that, even after the thorough washing described, the char has but a fraction of its former efficiency in decolorizing any liquors that might then be passed over it.

The universal custom for meeting this condition is to first pass the drained, but very wet, char through driers that partially dry it, and then through retorts of kilns heated by oil fires. The char, in passing through these char-kilns, is heated to from 700° F. to 800° F. out of contact with the air. The result of this procedure is to char the gums obstructing the pores to carbon, without endangering the bone-char to possible destructive combustion. This phase of the process is most important, as upon it depends the future condition of the char (which is the most important single element in the refining), and therefore, also, the degree of excellence of the subsequent work of the refinery. The kilning of the char may determine either highly satisfactory general refining results, or it may completely demoralize the entire plant. The immediate control of this work is conducted by tests made in the liquor gallery. After the char leaves the retorts of the kilns, it passes through a greater number of smaller tubes made of light iron for the purpose of cooling it. It is then fed down to the first floor,

from where it moves by means of elevators and conveyors back into the char filters, ready for another period of active work upon the liquors. No char (valued at present at $180 to $200 per ton) is ever discarded except the impalpable dust accumulated in the dust collectors, and that falling through a fine screen as it passes through the conveying system.

To come back to the liquors which we left at the liquor gallery, after having passed through the char. The liquors are pumped from the troughs of the gallery, through copper pipes, to the various storage tanks of the pan floors of the refinery proper, as distinguished from the char house. The principles involved from this point on are the same as in all other modern sugar plants of the world, be they engaged in refining sugar, extracting sugar from the cane of the plantations, or from the sugar-beet, namely, evaporation and crystallization through boiling under a reduced atmospheric pressure, separation of the sugar crystals from the mother-liquor by means of centrifugal force, and drying of the purified crystals through circulation of heated air.

The best liquors leaving the char are practically water white, having an apparent purity of approximately 99.0° to 99.5°, and these liquors are used for the manufacture of the large-grained confectioner's sugar (Con A and Con AA, we call them) and for manufacture of cube sugar, so that we may truthfully say that the cube sugar on your table is as near to absolute purity as any commercial product made, except some so-called chemically-pure chemicals. In fact, it probably *itself* can be accepted as a so-called chemically-pure product.

The next best grades of liquor, four in number, grade down gradually in color to a straw-colored No. 4 liquor, these all being the base for white granulated sugars. Itemized, then, the white sugars are as follows, the purities stated being in each case the apparent purity:

1. Cube Sugar—From 99.5° to 99.0° purity liquor—Syrup swung off, to No. 1 liquor tanks.
2. Con A Sugar—From 99.5° to 99.0° purity liquor—Syrup swung off, to No. 1 liquor tanks.
3. No. 1 Sugar—Four grades, all based on next best liquor from the char, called No. 1 liquor, with syrup from previous strike boiled back, as follows:
    (a) 1A Sugar—From No. 1 liquor straight, 98.5° to 97.0° purity—Syrup swung off, 97.6° purity, called 1A syrup, to next strike.
    (b) 1B Sugar—From No. 1 liquor and 1A syrup—Syrup swung off, 97.0° purity, called 1B syrup, to next strike.
    (c) 1C Sugar—From No. 1 liquor and 1B syrup—Syrup swung off, 96.5° purity, called 1C syrup, to next strike.
    (d) 1D Sugar—From No. 1 liquor and 1C syrup—Syrup swung off, 96.0° purity, called 1D syrup, sent back over the best grades of char.
4. No. 2 Sugar—One grade, from the next best liquor from the char, called No. 2 liquor, 97.0° to 94.5° purity—Syrup swung off, 92.0° purity, sent back to the best grades of char.

5. No. 3 Sugar—One grade, from the next best liquor from the char, called No. 3 liquor, 94.5° to 91.5° purity—Syrup swung off, 86.0° to 90.0° purity, sent back to the best grades of char.
6. No. 4 Sugar—One grade, from the last grade of liquor used for white granulated, called No. 4 liquor, 91.5° purity, down to a color standard, the average being about 89.0° purity—Syrup swung off, 80.0° purity, sent to either the soft sugar pans or the remelt pans.

From this it will be seen that we boil our white granulated sugars from seven distinct combinations of liquors and syrups, in a definite, predetermined, uniform system, conceived with the idea of getting a maximum granulated into the bag directly from the raw sugar, with a minimum production of remelt sugar. The sugars from all these pans are mixed together, dried, screened into the various grades through Newaygo and Whip-tap separators, passed over magnetic pulleys to remove metal specks, and finally packed. The combination results in a product perfectly satisfactory to the trade, all output first having to pass the critical eye of the Sugar Inspector, whose duty it is to reject any lots not, in his judgment, well within the grade limits, his judgment being final, regardless of any contrary views of the operating staff.

The present pan equipment for the production of white granulated sugars is as follows, all being coil pans and using both live steam at 60 lbs. pressure and exhaust at 12 lbs. pressure:

Cube	1 — 6-foot pan
Con A	1 — 12-foot pan
Granulated	4 — 14-foot pans

Two more pans are to be installed this year, of the calandria type, 14 feet in diameter.

During the latter part of 1919, the practice of seeding the granulated pans was instituted with very satisfactory results. The term "seeding," however, is rather a misnomer. Contrary to the practice of seeding as used in the manufacture of raw sugar by actually building up the grain introduced into the pans, the refinery practice consists merely of concentrating the liquor to the point approximating supersaturation and then drawing in a quantity of sugar dust ranging from a pint to a couple of gallons.

The quantity of sugar drawn in would seem to have little bearing upon the quantity appearing in the proof, nor does the quality of the introduced sugar appear to have the influence that might be expected upon first thought, in that results have been obtained with the coarser grades of sugar, as "seed," as well as with the fine dust. Insufficient work has been done in the way of investigation so far to be able to state definitely just what the action is and what laws are followed, but from my more or less superficial observations I am forced, for the present, to an adoption of a theory that the pan graining is due to a shock from the sudden introduction of dry sugar into a liquor already supersaturated, and not to an actual building up of the introduced grain. The benefit derived from this practice is observed in the evener grain appearing in the pan, due to its more rapid formation.

The satisfactory production of yellow *Soft Sugars* depends upon the presence of a maximum of glucose in the pan syrup, the proper depth of color, minimum of ash, minimum of iron organates, a fine grain, and a minimum pan temperature. To meet these conditions, syrup derivatives of affination syrup are used after a maximum of char-filtration, these syrups in one case consisting of the swing-off from the white granulated, boiled from the poorest liquor (No. 4), for the darker grade of softs, and a higher purity affination derivative for the lighter grade.

The soft sugars are, as you all know, the brown sugars of candy-making days, and are actually soft to the touch. On this Coast the two American refineries manufacture only three grades, Extra C, Golden C, and Yellow D, grading downward in color from a pale yellow to a rather dark yellowish-brown, respectively. In the East the market is much greater for such sugars, the refineries there beginning with a snow-white soft sugar, and grading down gradually through 15 products to the lowest, somewhat darker than our Yellow D. Our task in the West, then, is obviously much more exacting than what the Easterners have to contend with. Here we must use extreme care to get the exact shade of color at all times, whereas, in the Atlantic refineries, practically any shade of soft sugar that is produced will fit into some one of the 15 different grades.

Soft sugars, then, are crystallized sugars the same as granulated sugar, but with a definite amount of the mother-liquor, from which it was crystallized, retained on the surface of the crystals, the result being to make the marketed sugar always slightly moist.

But the soft sugars are distinctive from granulated sugar in another way also, in a way that gives it the distinctive soft texture. Comparative inspection of a white Berry sugar and a soft sugar under the microscope will show a very striking difference indeed. The Berry sugar crystals will be seen to be sharply cut and distinct, and this sugar, if it had the same amount of mother-liquor adhering to it as the soft sugar, would still feel hard and sharp to the touch. The soft sugar crystals, on the other hand, will be noted, under the glass, to be cemented together in minute bunches—conglomerate grain. Under the influence of a minimum temperature (at which softs are boiled, in contrast to the relatively high temperature at which white granulated sugars are boiled), the minute crystals first form, and then cement themselves together. When lightly pressed in the hand, this conglomerate crushes apart, giving the sensation of softness. One pan, 10 feet in diameter, of the calandria type, is used for this work.

To sum up—our refined output consists of the following products:

(1) Cubes and half-cubes—Packed principally in barrels, half barrels and boxes.

(2) Cubelets—Packed principally in barrels, half barrels, boxes and solid-packed cartons.

(3) Con A—Packed principally in barrels, half barrels, and bags.

(4) Con AA—Packed principally in barrels, half barrels, and bags.

(5) Berry granulated—Packed principally in barrels, half barrels, and bags.

(6) Standard granulated—Packed principally in barrels, half barrels, and bags.

(7) Coarse granulated—Packed principally in barrels, half barrels, and bags.

(8) Powdered (from milled granulated)—Packed principally in boxes, barrels, and some bags.

(9) Bar (from milled granulated)—Packed principally in boxes, barrels, and some bags.

(10) Extra C—Soft sugar, packed principally in bags and boxes.

(11) Golden C—Soft sugar, packed principally in bags and boxes.

(12) Yellow D—Soft sugar, packed principally in bags and boxes.

Under the present scheme of operation, our remelt sugar system is divided into two parts—in other words, we produce two sets of remelt sugar, three grades in each set. The first set, which we term our Regular Remelts, originates entirely from the boiled down syrups from the granulated and soft sugar pans; the second set, termed concentrated Sweet-Water Remelts, originates from the evaporated Char Sweet-Water and other sweet-waters from various parts of the plant. We have, then, No. 1, No. 2, and No. 3 Regular Remelts, and No. 1, No. 2, and No. 3 Sweet-Water Remelts; the No. 2 and No. 3 massecuite, in each case, passing through crystallizers before being purged. The object of the double system has been to keep products of essentially different non-sugar constitution separated, although the apparent purities of each set are kept approximately the same, as follows:

No. 1 Remelt Massecuite	.... 78° to 80°	purity
No. 2 " "	.... 70° to 72°	"
No. 3 " "	.... 64° to 66°	"

All remelt sugars are sent back over the char.

In concluding the description of the boiling system, it may be of interest to you for me to state that, of all the massecuite boiled in the plant, about 88.5% is white sugar massecuite, 4.2% soft sugar massecuite, and 7.3% is remelt massecuite. The output during the last month (March) was about 1375 tons of white sugar and 63 tons softs per day. It is thought that with an ample supply of raws we will be able to maintain, with our present equipment, an output of about 1600 or 1700 tons per day, and that the plant in 1921 will have a capacity of at least 2000 tons output.

The final molasses, or "black-strap," from the No. 3 massecuite, has an apparent purity, high according to your standards, of 40° to 44°. It is this molasses which will eventually have to be used as the base for barrel syrup, if the trade should call for it, and it is expected that this will resolve itself into a very difficult matter owing to the high ratio of ash to the other non-sugars of the Hawaiian raws. At the present time, our entire output of molasses, some 15,000 or 20,000 tons per annum, is sold for the purpose of fermentation and distillation into alcohol. The extreme aridity of the U. S. A. has, however, eliminated any possibility of "profiteering" through this means, so it is obvious that a very important question before us at the present time is, "How can we best dispose of our molasses?"

This is the story, very superficial indeed, of the refining of sugar. The intricacies of char-house practice; the manifold details of refinery control; the description of the great power plant; the story of the many intensely interesting technical investigations, current and completed; the study of the warehousing and marketing of the product,—each of these could be talked about to a very much greater length than this long paper has already run, and it is only illustrative of the enormous detail in the practice of refining. Some parts of it are so complicated, so deep, so very difficult to fathom, that I sometimes think we have fields ahead of us so vast as to make it seem possible that the next few decades will reveal to us more than all past history has so far taught us.

The latter seems to have foundation in the fact that at last the individual refiner is beginning to abandon his self-sufficiency, and is beginning to realize that a fair exchange of views and friendly treatment and relationship cannot but be instrumental in promotion and advancement of the industry as a whole and to each one in particular.

The refining industry today recalls the days of secrecy surrounding the art of sugar-boiling. There are those here who no doubt remember the profound mystery that surrounded the old-time sugar-boiler, who fostered the mystery by prohibiting everyone, even the superintendent, from putting his foot on the pan floor while he was engaged in operating the pan. This custom, however, was a product of the suspicion and jealousy of the Old World and did not appeal to the American spirit of initiative and demand for progress. When, then, the American woke up to the fact that this was no mystery at all, that it was not the practice of magic, and that there was nothing in the sugar business, any more than in any other human venture, that could not be improved upon, the old-time sugar-boiler-mystic passed on quickly and completely.

And thus, also, will the secrecy of sugar refining gradually give place to a more enlightened policy. It is indeed gratifying to be associated with an institution such as the California and Hawaiian Sugar Refining Co., which, developed by men bred and trained in the atmosphere of the broad-minded West, is opening the doors of its refinery to the world and spreading its records for the inspection of all eyes. Such policy is contagious, I am sure, and this is evidenced by the appearance of a more liberal policy in the practice of other refineries also. No doubt, the policy of the closed door will soon be a matter of the past.

And now our management has given further evidence of its clear vision by sending us here to open our eyes to the fact that there is more to our family than just little old Crockett, and for us to realize that it is not *our* refinery so much as it is *yours*. We came as strangers to your lovely land, have been warmed by your great hospitality, and will surely leave again with regrets, and with the hope that we may soon be privileged to reciprocate in some slight degree at least. We hope that we may be honored by your pride in our establishment and accomplishments in Crockett, as we are quickly learning to take pride in yours here.

We have seen your "Liquid Sunshine," the great helper to give what some poetic soul has termed your "Crystallized Sunshine." May we not urge you to visit us in California that we may demonstrate our methods of producing that which we might (at the risk of overdoing the simile) call "Filtered Sunshine"?

Fertilization at Pepeekeo for Three Successive Crops.

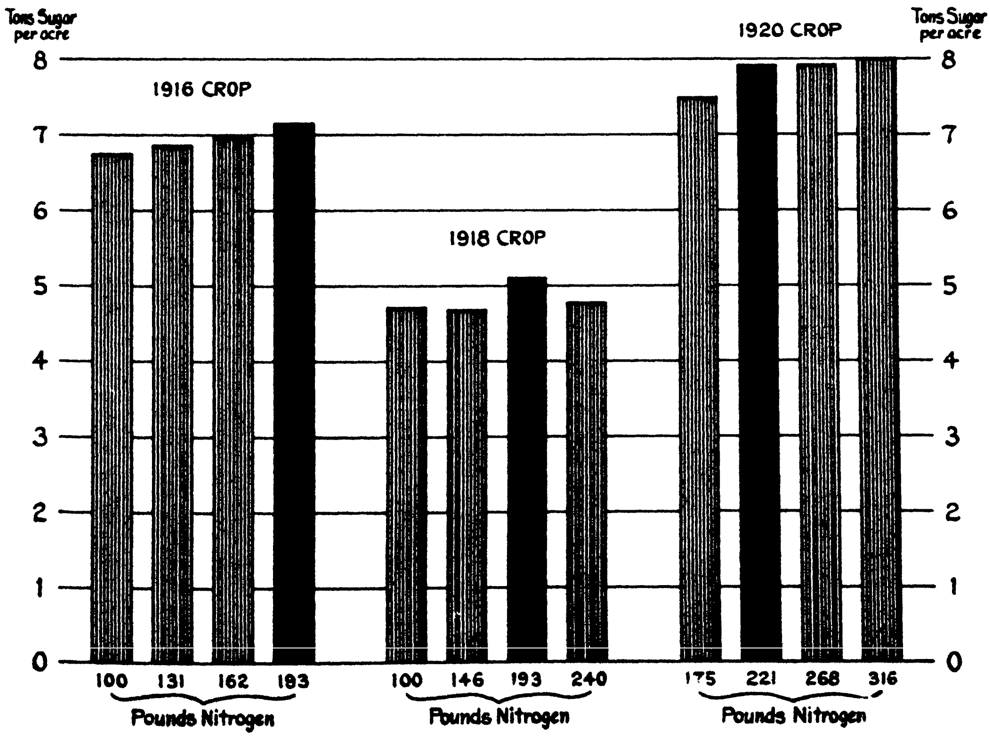
Pepeekeo Experiment No. 2, 1916, 1918 and 1920 Crops.

This experiment was laid out in 1915 by Mr. L. D. Larsen, and with slight modifications has been carried through three successive crops.

The cane involved was Yellow Caledonia, second ratoons for the 1916 crop. For the 1916 crop the experiment consisted of 13 plots, each 1/6 acre in size. In 1914 all plots received a uniform application of 1,000 pounds per acre of complete fertilizer, containing 10% nitrogen, 7% phosphoric acid and 4½% potash. The 4 X plots received no further fertilization, the 3 A plots received 200 pounds of nitrate of soda per acre in one dose during the second season, the 3 B plots received 400 pounds in two equal doses, while the 3 C plots received 600 pounds of nitrate in three equal doses.

For the 1918 and 1920 crops eleven more plots of the same size as the original ones were added to the experiment, making twenty-four plots in all, and the nitrate of soda applications to the A, B and C plots were changed to 300, 600 and 900 pounds per acre, in one, two and three doses, respectively, in 1918. For the 1920 crop the B and C plots received the nitrate in two equal doses. The

FERTILIZER RESULTS FROM THREE SUCCESSIVE CROPS.
PEPEEKEO SUGAR CO. EXP. 2, 1916, 1918 & 1920 CROPS
The solid black column represents about the economic limit in amounts of nitrogen to apply.



1918 crop received 100 pounds of nitrogen per acre during the first season. For 1920 crop this amount was increased to 175 pounds of nitrogen during the first season.

The results of the three harvests are given in the following tables:

1916 CROP — YELLOW CALEDONIA, SECOND RATOONS.

No. of Plots	Treatment		Total Lbs. of Nitrogen	Yield per Acre		
	First Season	Second Season		Cane	Q. R.	Sugar
4 X	100 lbs. Nitrogen	....	100	52.3	7.75	6.75
3 A	100 lbs. Nitrogen	200 lbs. N. S. (31 lbs. N.)	131	56.3	8.20	6.87
3 B	100 lbs. Nitrogen	400 lbs. N. S. (62 lbs. N.)	162	58.5	8.38	6.98
3 C	100 lbs. Nitrogen	600 lbs. N. S. (93 lbs. N.)	193	60.7	8.48	7.16

Reported in detail in Record Vol. XIV, page 299.

1918 CROP — YELLOW CALEDONIA, THIRD RATOONS

No. of Plots	Treatment		Total Lbs. of Nitrogen	Yield per Acre		
	First Season	Second Season		Cane	Q. R.	Sugar
6 X	100 lbs. Nitrogen	....	100	39.6	8.39	4.72
6 A	100 lbs. Nitrogen	300 lbs. N. S. (46 lbs. N.)	146	39.0	8.32	4.68
6 B	100 lbs. Nitrogen	600 lbs. N. S. (93 lbs. N.)	193	42.4	8.21	5.12
6 C	100 lbs. Nitrogen	900 lbs. N. S. (140 lbs. N.)	240	42.4	8.84	4.79

1920 CROP — YELLOW CALEDONIA, FOURTH RATOONS.

No. of Plots	Treatment		Total Lbs. of Nitrogen	Yield per Acre		
	First Season	Second Season		Cane	Q. R.	Sugar
6 X	175 lbs. Nitrogen	....	175	55.6	7.42	7.50
6 A	175 lbs. Nitrogen	300 lbs. N. S. (46 lbs. N.)	221	59.5	7.52	7.94
6 B	175 lbs. Nitrogen	600 lbs. N. S. (93 lbs. N.)	268	60.9	7.68	7.94
6 C	175 lbs. Nitrogen	900 lbs. N. S. (140 lbs. N.)	315	63.2	7.88	8.01

NOTE: In second season fertilization the A plots received the nitrate in one dose, the B plots in two equal doses, and the C plots in three equal doses in 1916 and 1918, and two equal doses in 1920.

The results of these three harvests are fairly consistent, and, for the conditions involved, indicate the profitable limits of fertilization to be about 200 pounds of nitrogen per acre.

In the first crop, increases in yield were obtained to the limit of fertilizer application, which was 193 pounds of nitrogen; in the second crop no increase in yield was obtained when increasing the nitrogen from 193 pounds to 240 pounds per acre, while in the third crop no increase was obtained above 222 pounds of nitrogen.

Details of Experiment.

Second Season Fertilization—Amount to Apply.

Object:

1. To determine the profitable limit of second season fertilization.
2. To note the effect continuous heavy applications of nitrate of soda may have on the soil.

Location:

Pepeekeo Sugar Co. field 17, on plantation road 42 lines from Government road.

Crop:

Yellow Caledonia, 4th ratoons, long.

Layout:

Number of plots: 24.

Size of plots: 1/6 acre, consisting of 6 rows, 5.55 ft. wide and 216 ft. long.

Plan:

Fertilization: First season, uniform with adjoining field.

Second season:

POUNDS NITRATE OF SODA PER ACRE

1916 CROP

Plots	Plot Numbers	April 1, 1915	May 15, 1915	July 1, 1915	Total
X	1, 5, 9, 13	....	....	....	....
A	2, 6, 10	200	....	....	200
B	3, 7, 11	200	200	....	400
C	4, 8, 12	200	200	200	600

1918 CROP

Plots	Plot Numbers	March 29, 1917	May 31, 1917	July 25, 1917	Total
X	1, 5, 9, 13, 17, 21	....	....	....	....
A	2, 6, 10, 14, 18, 22	300	....	....	300
B	3, 7, 11, 15, 19, 23	300	300	....	600
C	4, 8, 12, 16, 20, 24	300	300	300	900

1920 CROP

Plots	Plot Numbers	March 1, 1919	May 15, 1919	Total
X	1, 5, 9, 13, 17, 21	....	....	....
A	2, 6, 10, 14, 18, 22	300	....	300
B	3, 7, 11, 15, 19, 23	300	300	600
C	4, 8, 12, 16, 20, 24	450	450	900

J. A. V.

A Sugar Cane Cancer-root.

Aeginetia indica Roxb.

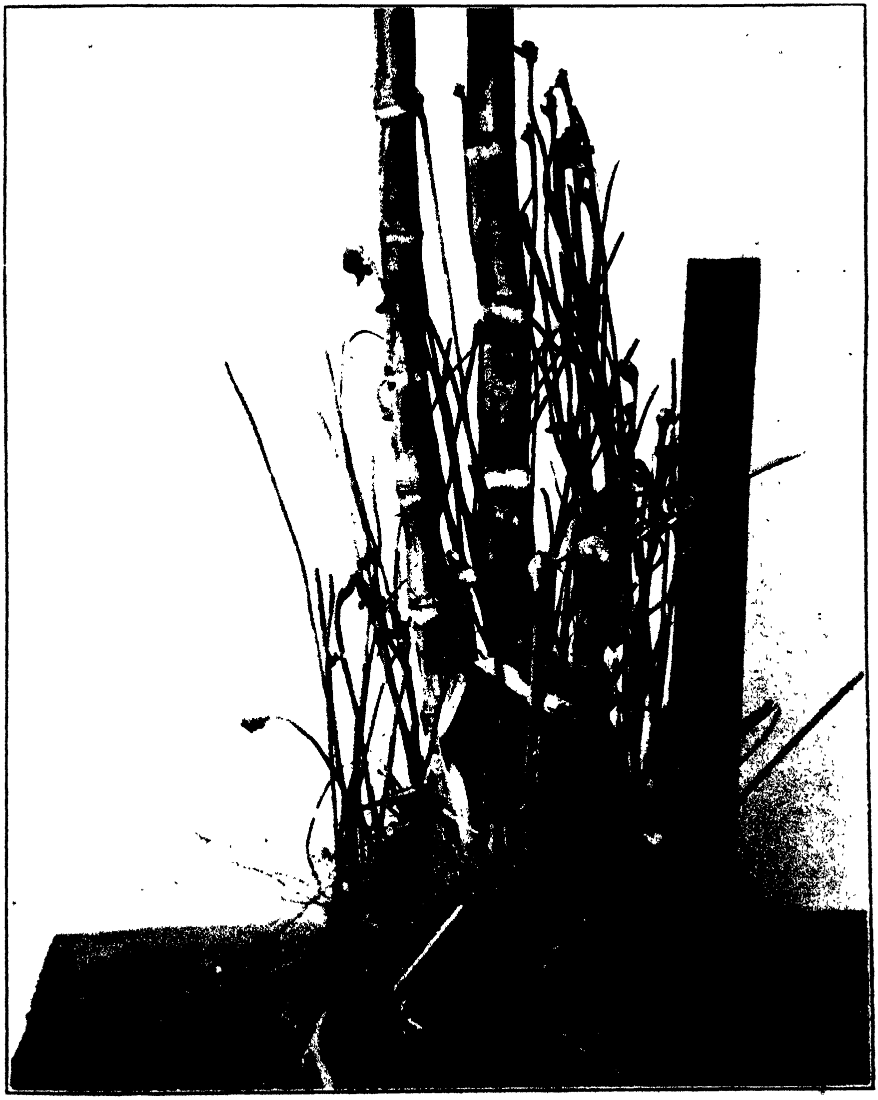
The accompanying photographs show groups of a curious little flowering plant which is parasitic on the roots of sugar cane in the Philippine Islands. This plant belongs to a family, the components of which have abandoned the use of chlorophyll, and steal their food from other plants by attaching themselves to the roots of their hosts and drawing food materials directly from their tissues. Being devoid of chlorophyll they are never green, but appear white, yellowish or brown, depending upon their age and condition. A few species are characteristically pink and red.

SUGAR CANE CANCER-ROOT, *AEGINETIA INDICA* ROXB.

As a rule, plants of this family are rather scarce in nature, but this particular species is said to be of frequent occurrence in cane fields in the Philippines, and in some cases cause serious damage. The plant body consists of a short, almost leafless and colorless stem which remains nearly or quite buried in the soil in close contact with the cane roots. From this stem there springs one to three long slender flower stalks, each bearing a single nodding flower which eventually yields a seed capsule containing many seeds.

Unless this plant has habits not shared by its American congeners, it should be possible to eradicate it by the judicious use of the hoe. If the plants are not permitted to flower and seed they should entirely disappear from the fields within a few years.

The photographs of this interesting plant, which we reproduce herewith, were supplied by Mr. C. R. Hemenway. H. L. L.



SUGAR CANE CANCER-ROOT, *AEGINETIA INDICA* ROXB.

Badila Gives the Best Yield at Kilauea.

Kilauea Experiment No. 19, 1920 Crop.

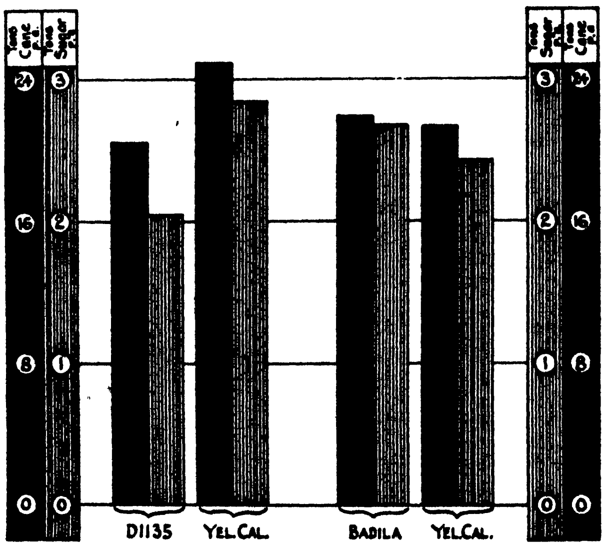
This was a test comparing Badila, Yellow Caledonia and D 1135. The cane involved was plant, in a mauka, non-irrigated field. The cane was 19½ months old when harvested, having been planted May 20, 1918, and harvested January 6, 1920. The experiment consisted of 48 plots, each 1/10 acre in area. The results of the harvest were as follows:

Number of Plots.	Variety.	Yield per Acre.			Gain or Loss over Y. C. Checks.	
		Cane.	Q. R.	Sugar.	Cane.	Sugar.
Twelve	D 1135	20.5	9.98	2.05	— 4.7	— 0.82
Twelve	Yellow Cal.	25.2	8.78	2.87		
Twelve	Badila	21.9	8.20	2.67	+ 0.8	+ 0.27
Twelve	Yellow Cal.	21.1	8.78	2.40		

In this test D 1135 proved to be distinctly inferior to either Yellow Caledonia or Badila, producing less cane per acre, containing a much poorer juice.

The Badila and Yellow Caledonia produced about the same amount of cane per acre, but the Badila juice was better, thereby leading the Yellow Caledonia by 0.27 ton of sugar per acre.

VARIETY TEST
GRAPH SHOWING THE COMPARATIVE YIELDS OF YELLOW CALEDONIA, BADILA AND D1135.
KILAUEA SUGAR PLANTATION CO. EXP. 19, 1920 CROP



VARIETY TEST

Map Showing The Yields By Plots Of Yellow Caledonia, Badila, And D1135.

Kilauea Sugar Plantation Co. Exp.*19, 1920 Crop

First Ratoons

Mauka

3' Path

37 D1135 20.26	38 Y. C. 26.12	39 D1135 16.75	40 Y. C. 23.32	41 D1135 18.76	42 Y.C. 23.64	43 Badila 22.86	44 Y.C. 18.31	45 Badila 19.72	46 Y.C. 15.37	47 Badila 19.05	48 Y. C. 16.67
25 Y. C. 25.38	26 D1135 24.00	27 Y. C. 25.56	28 D1135 18.91	29 Y.C. 24.06	30 D1135 17.99	31 Y. C. 22.53	32 Badila 21.49	33 Y.C. 23.34	34 Badila 20.41	35 Y.C. 18.04	36 Badila 19.35
13 D1135 24.68	14 Y. C. 27.03	15 D1135 22.90	16 Y.C. 22.95	17 D1135 16.73	18 Y. C. 22.40	19 Badila 21.81	20 Y.C. 21.93	21 Badila 26.39	22 Y.C. 22.62	23 Badila 24.37	24 Y. C. 21.49
1 Y. C. Discard	2 D1135 22.02	3 Y.C. 31.37	4 D1135 22.91	5 Y. C. 25.67	6 D1135 19.74	7 Y.C. 23.81	8 Badila 19.94	9 Y. C. 23.65	10 Badila 26.25	11 Y. C. 25.35	12 Badila 21.09

3' Path

Tons Cane p.a.

Summary Of Results

No. of Plots	Variety	Yields Per Acre		
		Cane	Q.R.	Sugar
12	D1135	20.5	9.98	2.05
12	Yellow Caledonia	25.2	8.78	2.87
12	Badila	21.9	8.20	2.67
12	Yellow Caledonia	21.1	8.78	2.40

In planting, Badila body seed was used and spaced 5 inches The Yellow Caledonia was from good top seed planted end to end, while the D 1135 had both top and body seed, planted end to end. The Caledonia came up to a better stand, and closed in before either of the other two, the Badila being a poor third at that time. Notes made on April 24, 1919, place Yellow Caledonia first, D 1135 second, and Badila third, while on June 16, 1919, Badila was placed first, "because, generally, it has controlled weeds better, and appears to have suffered less from drought."

In harvesting this experiment Mr. Thurston states that he could not find a single stick of Badila damaged by rats,[1] while Yellow Caledonia and D 1135 were quite badly rat-eaten; on the other hand borer infestation was very much heavier in the Badila than in either of the other varieties.

[1] As against this, some Badila just harvested at Waipio was very badly rat-eaten, much more so than adjoining Caledonia.

DETAILS OF EXPERIMENT.

Object:

To test the comparative value of the following varieties: Badila, D 1135 and Yellow Caledonia.

Location:

Field 25.

Crop:

Plant Cane.

Layout:

Number of plots, 48.
Size of plots, 1/10 acre (54'x80.7'), each plot consisting of 12 straight lines (4.5'x80.7').

Plan:

Variety.	No. Plots.	Plot Numbers.											
Badila	12	8	10	12	19	21	23	32	34	36	43	45	47
D 1135	12	2	4	6	13	15	17	26	28	30	37	39	41
Yellow Caledonia	24	1	3	5	7	9	11	14	16	18	20	22	24
		25	27	29	31	33	35	38	40	42	44	46	48

Fertilization uniform by plantation
Experiment planned by J. A. Verret and G. B. Grant.
Experiment laid out by G. B. Grant.
Experiment harvested by R. S. Thurston.

[J. A. V.]

Preventing Boiler Explosions.*

By C. S. TOMPKINS.

From a study of boiler explosions, which are of much too frequent occurrence, it is apparent that boiler inspectors are often tempted to allow too high working pressures, with the result that property and lives of the engineers, as well as other employees, are unnecessarily exposed to danger.

An example of this practice is the boiler of a Minneapolis laundry, which exploded several months ago. The boiler in question was of the return tubular type, 66 in. in diameter by 18 ft. in length. The shell steel was 7/16 in. thick, with a tensile strength of 55,000 lbs. The longitudinal seams were triple-riveted butt joint construction, but, on account of having been damaged, the lower half of the sheet, directly over the fire, had subsequently been replaced by what is known as a half-sheet patch. The longitudinal seams employed in making this repair were of the double-riveted lap joint construction, and located below the hangers by which the boiler was suspended. The joints were thus exposed somewhat to the heat of the fire.

The boiler, which, according to the insurance company's records, was 15 years old, was inspected regularly by the insurance underwriter's inspector, and was therefore exempted by the Minnesota State laws from State inspection. The insurance inspector allowed a maximum safe working pressure of 110 lbs.

*Reprinted from Power Plant Engineering, May 1, 1920.

Fig. 1.
Destruction caused by typical boiler explosion.

Fig. 2.
The top edge shows what was left of a double riveted lap joint used in putting on a patch.

The first step in the investigation was to test the safety valve, which was found to release at 110 lbs. Within 2 minutes prior to the explosion, the safety valve was known to have blown. The force of the explosion was sufficient to move the boiler 50 ft. from its setting and force it through a 3-ft. stone wall. A part of the boiler front was thrown nearly a city block. Figure 1 shows the boiler end projecting through the stone wall. Figure 2 shows one of the points of failure, the man's right hand touching the original triple-riveted joint, and his left touching the remains of the lap joint.

Paragraph 187 of the Boiler Code of the American Society of Mechanical Engineers, which is standard in Minnesota, reads as follows: The riveted longitudinal joints of a shell, or drum, which exceeds 36 in. in diameter, shall be of butt and double strap construction. This does not apply to the portion of a boiler shell which is staybolted to the firebox sheet.

Paragraph 188 reads: The longitudinal joints of a shell, or drum, which does not exceed 36 in. in diameter may be of lap riveted construction, but the maximum allowable pressure shall not exceed 100 lbs. per square inch.

Paragraph 189 reads: The longitudinal joints of a horizontal return tubular boiler shall be located above the fire line of the setting.

It will be seen that the inspector who allowed 110 lbs. in the example given was very liberal. A factor of safety of five would give a working pressure of 105 lbs., and a further allowance should have been made for the patch. Paragraph 188 absolutely forbids more than 100 lbs. working pressure.

All engineers' organizations ought to insist upon the adoption of the Boiler Code of the American Society of Mechanical Engineers, and a strict adherence thereto by inspectors. This would eliminate to a great extent the large number of boiler explosions which occur annually. [W. E. S.]

Plantation Apprentices.

By Donald S. Bowman.

Industrial Service Bureau, H. S. P. A.

It would seem from a study of the rural school population that the male youth of the plantations would more than furnish all of the skilled and semi-skilled labor demanded. That the plantation-raised boys drift away from their homes, largely owing to the fact that they see no future on the plantations, is realized by those who have given the subject consideration.

Much has been done on the mainland in the big industrial centers along the lines of vocational guidance, and it has been advocated that this subject be developed as a branch of our educational system.

Vocational guidance means helping the boy and his parents to consider his future occupation, and helping them decide what he is best fitted for in life and to take the necessary steps leading to his being properly placed where he may obtain the necessary training.

This work should be undertaken by someone connected with the plantation, as it is necessary to do considerable work with both the boy and his parents in order that their interest and ambitions may be aroused. Full information should be at hand as to the various employments open to apprentices on the plantation and these facts presented to the most promising boys. It should be made plain to them that such work will be a real vocation with a future, instead of a job. This information should consist of the following:

1st: The qualifications necessary to become an apprentice, listing the skilled and semi-skilled occupations.

2d: The action to be taken in applying.

3d: The length of service as an apprentice, and rate of pay.

4th: Average pay of occupation, and other benefits.

Suggestions.

The educational campaign should be handled by the Industrial Service Inspector working directly under the Plantation Manager.

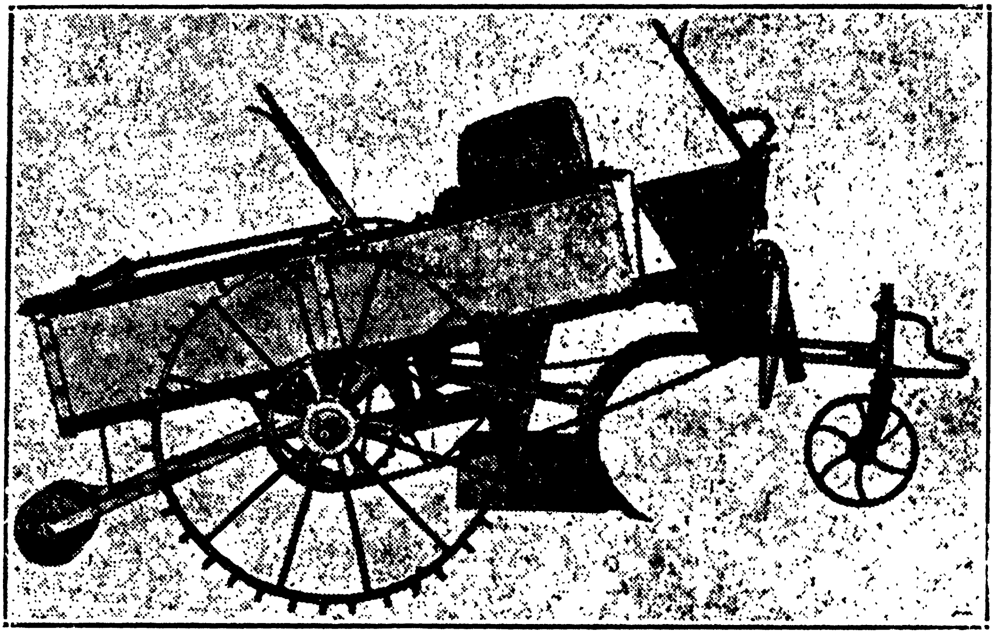
That the interested boys in the last two grades of the public school be formed into a class where they will be taught Americanism and the advantages offered on the plantation in the different skilled and semi-skilled trades.

The Inspector's work in connection with vocational guidance would include advice and direction, he to serve as a means of communication between the plantation management and applicants for apprenticeships, to collect required information as to the trades and the qualifications necessary, to make this and other information available through classes conducted for that purpose, to assist pupils by laying out any necessary courses of study after they have become apprentices. After boys have been placed, and at least during their probation period, the Inspector should keep in close touch with them, offering advice, etc., and if a boy is found to be ill-fitted for the work, help him to select some other occupation.

The suggested trades and semi-skilled trades that could be filled by the apprentice system without special education, taking the boys who have finished the eighth grade, would include:

Steam Engineer	Truck and Tractor Operator
Pump Engineer	Painter
Gas Engine Engineer	Carpenter
Machinist	Irrigation Worker
Blacksmith	Stone Mason and Concrete Worker
Sugar Boiler	Electrician's Assistant
Steam Plow Operator	

It is apparent that many advantages will accrue through the development of the boys born and raised on the plantation, but it is essential that the plantation, to obtain such desired results, should take an active interest.



A Machine for Cane Planting.

From a correspondent in Australia we publish the following account of the cane planting machines in use there:

"There are many types of cane planters used throughout Queensland. The one most commonly adopted is a box mounted upon wheels capable of holding about 1½ to 2 cwt. of cut plants, plants being cut into lengths containing 3 'eyes.' This box has handles attached and a seat in the box for a boy to sit. At the end nearest the driver is an iron tube. Underneath on each side of the tube are two flat iron plates coming to a point in front of the tube. One horse is attached to the machine.

"The drills are opened by a drill or double moldboard plow and the planter is then brought into the drill. As the machine is driven up the drill the boy drops his plants through the tube and the iron plates throw on the soil to cover them. Planting can be carried out more rapidly than by hand. Some four acres a day can be covered by the driver and boy. The planting, of course, is not done so carefully, as the plants fall in any position, and not with the eyes at the side, but the strike is satisfactory if the boy drops the plants regularly and not too fast. It is in common use in most of the sugar districts of Queensland, and has the advantage of putting the plants well down into the moisture during dry spells. Its use is considered much more economical than hand planting.

"Other types are patented and in use. Some of these are drays with the covering part hung underneath, so that a great many more plants may be carried to the field. They, however, require more horse power. The attached cut shows a patent of Willmans.

"Most farmers, however, make their own planters, or obtain the small machine first described." [W. P. A.]

Factory Results in Java, 1919.*

	Defecation Factories	Sulfitation Factories	Carbonation Factories	General Average
Cane:				
Polarization	12.15	12.49	12.84	12.38
Fiber	12.98	13.06	12.99	13.01
Bagasse:				
Polarization	4.04	3.95	4.06	4.01
Moisture	47.11	47.02	46.64	47.01
Fiber	47.43	47.79	47.79	47.62
Mixed Juice:				
Brix	15.29	15.68	16.02	15.54
Polarization	12.56	12.99	13.36	12.83
Sucrose	12.75	13.13	13.51	13.00
Gravity Purity	83.3	83.8	84.3	83.7
Glucose	1.13	1.11	1.03	1.11
Weight per 100 Cane	87.82	87.52	87.48	87.66
Press Cake:				
Polarization	5.25	5.38	0.79	3.79
Weight per 100 Cane	1.74	2.02	5.98	2.42
Syrup:				
Brix	55.77	53.87	55.02	54.95
Polarization	47.10	45.96	47.43	46.70
Sucrose	47.57	46.21	48.05	47.13
Gravity Purity	85.3	85.8	87.3	85.8
First Massecuites:				
Brix	91.94	92.32	92.79	92.25
Apparent Purity	84.0	84.2	84.7	84.2
Second Massecuites:				
Brix	92.97	93.44	93.68	93.22
Apparent Purity	77.6	77.1	76.4	77.3
Third Massecuites:				
Brix	94.52	94.72	95.23	94.67
Apparent Purity	69.0	69.1	70.3	69.2
Fourth Massecuites:				
Brix	99.96	97.79	96.98	97.29
Apparent Purity	59.4	59.8	57.4	59.3
Molasses Purities:				
First	64.5	65.1	65.8	65.0
Second	57.5	56.7	55.5	57.0
Third	49.5	48.4	47.2	48.9
Sugars:				
White Plantation:				
Polarization	....	99.61	99.59	99.61
Per cent of total sugars	....	36.29	13.59	49.88

* From Annual Synopsis of Mill Data, Experiment Station of the Java-Suikerindustrie, averages from 142 Javan factories.

FACTORY RESULTS IN JAVA (Continued).

	Defecation Factories	Sulfitation Factories	Carbonation Factories	General Average
Sugars (Continued):				
No. 16–20 D. S.:				
Polarization	98.42	....	....	98.42
Per cent of total sugars	23.19	....	....	23.19
No. 14 D. S.:				
Polarization	97.33	....	....	97.33
Per cent of total sugars	23.38	....	....	23.38
Second Sugars:				
Polarization	....	98.39	98.27	98.34
Per cent of total sugars	....	1.09	0.92	2.01
Molasses Sugars:				
Polarization	85.76	86.91	87.81	86.48
Per cent of total sugars	0.52	0.34	0.17	1.03
Black Stroop:				
Polarization	81.88	81.57	83.36	82.15
Per cent of total sugars	0.23	0.15	0.13	0.51
Final Molasses:				
Brix	91.93	93.02	91.67	92.34
Sucrose	33.62	33.32	32.74	33.39
Gravity Purity	36.6	35.8	35.7	36.2
Glucose	27.65	28.39	25.76	27.65
Ash	9.96	9.59	9.22	9.72

[R. S. N.]

Analyses of Cuban Sugars.*

Results for Nineteen Years as Observed at One Refinery.

By W. D. Horne, Ph. D.

In the accompanying table is given a set of average analyses of Cuban centrifugal sugars received during the past nineteen years at one of the Atlantic seaboard refineries. A careful study of these analyses shows that for the past few years the Cuban sugars of this class have averaged a little above 95.5 polarization, about 0.6 per cent ash, about 1.3 per cent glucose, and a trifle less organic matter. The moisture content has been a little more than 1.1 per cent.

Good Quality Maintained.

These figures are fairly satisfactory, indicating the composition of a sugar which keeps well in storage and which can be refined with satisfactory results. It is particularly gratifying to note that in the effort to produce vast quantities of sugar Cuba is, as a rule, maintaining a satisfactory quality in the product. Refiners are becoming more discriminating in regard to the refining character of the sugars purchased and are closely watching the individual marks, with the result that those estates producing sugars most advantageous for refining have the greater demand for their output.

* Facts About Sugar, March 20, 1920.

AVERAGE ANALYSES OF CUBAN CENTRIFUGAL SUGARS.

Year.	Polarization	Glucose.	Water.	Ash.	Organic Matter.
1901	94.00	1.88	1.74	0.50	1.88
1902	94.36	1.75	1.43	0.58	1.86
1903	95.09	1.22	1.59	0.51	1.59
1904	94.37	1.57	1.47	0.56	2.03
1905	95.00	1.45	1.37	0.60	1.58
1906	94.76	1.39	1.43	0.67	1.75
1907	95.02	1.21	1.39	0.67	1.71
1908	94.97	1.15	1.20	0.69	1.99
1909	95.31	1.26	1.21	0.59	1.65
1910	95.23	1.22	1.33	0.66	1.56
1911	95.57	1.18	1.18	0.68	1.39
1912	95.65	1.28	1.13	0.58	1.36
1913	95.48	1.28	1.30	0.60	1.34
1914	95.79	1.20	1.10	0.61	1.30
1915	95.89	1.31	1.02	0.56	1.22
1916	95.52	1.47	1.10	0.67	1.24
1917	95.80	1.27	1.13	0.54	1.26
1918	95.43	1.28	1.32	0.58	1.39
1919	95.64	1.37	1.15	0.57	1.27

[R. S. N.]

Sugar Industry of Philippine Islands.*

By J. F. Boomer.

The growing of sugar cane and the manufacture of commercial sugar are two phases of an industry in the Philippine Islands which should be of great interest to American manufacturers. While the growing of cane is purely an agricultural question, it has come into great prominence in latter years, since modern agricultural machinery has become more and more a factor in the sugar industry. Up to date, however, capital has been more profitably employed in the manufacture of commercial sugar, and at the present time more inviting opportunities are offered in this field than are held out in the sale of agricultural machinery. The manufacture of centrifugal sugar requires large investment, and while a few individual planters have established small mills on their holdings and in some instances groups of planters have banded together for the establishment of larger mills, the tendency in the islands is toward the separation of the agricultural from the manufacturing branch of the sugar industry. This has led to a demand for outside capital in order to supply the necessary uipment for the manufacturing end.

*In Commerce Reports, October 23, 1919.

For many years the average planter of the Philippines was content with the old-style methods and the consumer of Philippine sugar was satisfied with the muscovado and pilon product of these methods, but this time has passed and every up-to-date planter is now convinced that it would be vastly to his advantage to have his cane made into centrifugal sugar and is ready to cooperate in the establishment of a central in his neighborhood by entering into the usual contract for the delivery of his cane to the factory.

Larger Profits Made on Centrifugal Sugar.

During the past year 18 modern mills produced for export 64,018 metric tons of centrifugal sugar, as against 47,224 tons exported in 1917, at an average price for 1918 of $91.60 per ton. During the same year 209,240 tons of muscovado sugar were exported, compared with 158,685 tons for 1917, at an average price of $42.60 per ton for 1918.

Heretofore the planters have made a fair profit on muscovado sugar when their product has been up to grade, but where the product has been inferior the prices obtained have hardly paid the cost of production. It is estimated that the cost of producing the cane for a picul (137.5 pounds) of sugar is $1, whereas the cost of manufacturing the cane into sugar by the old methods, furnishing sacks, and otherwise preparing the product for market is placed at 50 cents. The cost of shipping to market, allowing for insurance and depreciation, added to this, brings the estimated cost of a picul of muscovado or pilon sugar up to $2, and when it is remembered that the three-roller mill employed leaves approximately 50 per cent of the juice in the cane, it will be seen that the cost to manufacture centrifugal sugar, even by contract, is practically no more than the cost to make muscovado or pilon sugar, whereas the prices obtained for the former are double those obtained for the latter. This difference in price and the further fact that the cost of producing muscovado sugar has advanced more quickly than its market price form the convincing argument that has turned the thoughts of sugar planters to the central. Moreover, the Chinese market for muscovado sugar has been waning in recent years, and a preference has been shown there for Philippine centrifugal sugar of 96° polarization.

Market for Small Mills—Transportation of Cane and Sugar.

One enterprising manufacturer of sugar machinery, who recently opened an office in Manila, has sent his experts to the islands to study the needs of the field and is adapting his machinery, which was designed primarily for other sugar-growing countries, to meet the requirements of the Philippine market. It is probable that there will continue to be a market in the Philippines for small centrifugal mills of from 500 to 1,000 tons daily capacity. This type of mill appears to be best suited in point of cost and availability to the large plantation owner who desires to mill his own crop and, perhaps, that of his neighbor.

A tendency is to be noted on the part of the planters in some neighborhoods to unite in the purchase of a mill to be as centrally located as possible. The land in some sections of the sugar regions, however, is divided into such small holdings that the only feasible way to give these smaller planters the advantages of the modern mill is through the large central, with its contract system and provisions for transportation.

The Manila Railroad's published rates for transporting a ton of cane are as follows: Fifty kilometers (a kilometer equals approximately five-eighths of a mile), $0.625; 100 kilometers, $0.93; and 150 kilometers, $1.155. During the greater part of the past two years it has been impractical to undertake to haul cane great distances, owing to the congested traffic on the Manila Railroad lines. This company has been short of rolling stock to meet the increasing demands made upon it, and the war conditions abroad made it impossible to procure any equipment. The delays in the transportation of cane have caused a marked decline in its milling value, as four days are regarded as the maximum time that should elapse between the cutting and the milling of the cane.

The general rates quoted by the Manila Railroad Company for the transportation of sugar are as follows: Fifty kilometers, $1.54 per ton; 100 kilometers, $2.12; and 150 kilometers, $2.57. There is no difference in the freight charged for centrifugal sugar and that charged for muscovado sugar. At times during the past year interisland steamship rates on sugar have been $2.75 per ton, although it is difficult to give definite quotations, and ocean rates to the United States about $30 per short ton.

Labor Required for Sugar Central.

A large sugar central should have an office force consisting of a superintendent, who is generally paid from $3,000 to $4,000 per year; an assistant superintendent, $2,000 to $4,000; a chief chemist, $2,000 to $3,000; and four assistant chemists (usually Filipinos), $50 per month. The ordinary labor required during the milling season is a night and day shift, each of 50 to 75 men. It is generally considered that 50 laborers are sufficient for a mill with a capacity of 800 tons daily. The San Carlos mill, which now has a capacity of 1,800 tons daily, employs 160 workmen. Labor of this sort is generally paid from 35 to 60 cents per day without subsistence.

Men for the office force would probably have to be obtained outside the Philippines, in most cases. There are few engineers and chemists in the islands capable of operating centrals. The Filipinos are undoubtedly capable of acquiring the necessary training and experience, but modern sugar mills have not been in operation long enough in the islands to develop a supply of trained men to operate them. A number of Filipinos are now taking courses in chemistry and engineering in the United States and Europe, and these will doubtless help to supply the need in a few years. Just at present there are good openings in the islands for men who have had training and experience in the manufacture of centrifugal sugar.

The ordinary labor required is usually easily obtained, although it is often difficult to get cutters to harvest the cane crop and laborers to work about the old-fashioned sugar mills where the muscovado and pilon sugars are made. The explanation seems to be that wages paid by the central are usually a little higher than those paid for field labor or by the muscovado mills. These men are for the most part inexperienced in the work required about a central, and, therefore, are not very efficient, but the supply of experienced labor is increasing each year.

As new centrals are established workmen employed in some of those that have been operating for some time seek employment in the new enterprise in the hope of bettering their situations or for the mere desire to try something new, while new men take their places in the older factories.

Building and Machinery Costs—Private Transportation Equipment.

Mr. Cleve W. Hines, formerly sugar technologist of the Philippine Bureau of Agriculture, estimates that the buildings and machinery for a mill with a capacity of 800 tons per day would cost about $25,000. In this connection it should be remembered that cement and construction steel cost nearly 100 per cent more now than they cost before the war. The San Carlos central, including machinery and building material, was erected at considerably greater cost than it would have been before the war. Structural steel that before 1914 cost about $43 per metric ton now approximates $81, though with a tendency downward; corrugated iron roofing that cost $67 a ton in pre-war days now brings $150; cement has risen in this same period from $8 per ton to $12. Lumber and all builders' hardware have gone up proportionately.

Machinery imported from the United States into the Philippines pays no duty. It costs about as much to lighter or land freight in Manila as it would cost in an American port. Apparatus is not available for handling extremely large pieces. It must be borne in mind, however, that the points where the machinery is to be installed are usually far from Manila, and there are few facilities for loading and unloading heavy machinery in most of these places. Machinery designed for use on Negros, Panay, or Cebu probably would have to be transshipped at Manila on an interisland steamer for the port nearest the point where it is to be installed. Iloilo and Cebu each has some facilities for handling heavy cargo. From either of these points the machinery would probably have to be taken in lorchas or cascoes (native barges or lighters) towed by launch to connect with the land transportation necessary to get it to its destination. The cost of transportation from Manila to the point at which the machinery is to be installed depends, in each case, upon the location of that point and the conditions of local transportation at the time the machinery is received.

The larger sugar factories employ cars with trackage of the same gauge as that of the railroad in order to enable them to send their cars over the line when necessary. These cars carry approximately 20 tons of cane and are equipped with two sets of four wheels each. The factories also use a portable track of a much smaller type for conveying cane to the main lines. This ranges from 28 to 36 inches in width, and the cars carry from one-half to 2 tons of cane. These cars have but four wheels. Small locomotives are operated over some of these tracks and animal draft is provided for others. The three largest plantations have approximately 25 miles of heavy track and 6 or 8 miles of the light portable track; all of the small centrifugal sugar factories of Negros operate with a light track, and most of them run steam engines.

Methods of Marketing Philippine Sugar.

Before the introduction of the modern mill muscovado and pilon sugar was commonly sold by the planter to the exporters, usually Chinese merchants or European export and import houses, who maintain warehouses in Iloilo, the chief sugar port, for receiving and storing the stocks from the plantations. Sugar produced in Negros was commonly transported to Iloilo on barges towed by launches, while that produced along or near the railroad on Luzon was delivered by cart to cars at the nearest station. In the Visayan sugar regions the exporters usually advance money to the planters at certain times against the crops, and the planters are bound to sell their crop to the exporters at prices usually stipulated in advance, and, as a rule, very low. By the use of money made available by the Government, at first through the Bank of the Philippine Islands and later through the Philippine National Bank, the planter gradually ceased to be dependent upon the export merchant and has since been able to sell his output for the best price obtainable in the open market. The use of the modern mill for centrifugal sugar manufacture has brought about a change in the methods of marketing in many localities. It is now very common for the small planter to sell his share of the finished sugar to the central which does his milling. The central in turn frequently exports on its own account. At other times the central, or the larger planter who operates his own mill, sells to export merchants or brokers engaged in buying for foreign houses, and the increasing proportion of the pilon and muscovado sugar is now sold by the small planter to the large mills and centrals for conversion into centrifugal sugar.

On the whole, the Philippine sugar industry is being freed from the handicaps under which it has labored since its inception, and an entirely new life is being infused into it. Some conception of the field yet open in the islands for the installation of modern sugar machinery may be had by remembering that the exports of Philippine sugar are yet well under 300,000 tons per year (by far the greater portion of which is still manufactured by primitive methods), although those best informed concerning the area of land suitable for sugar culture in the islands estimate that the production may easily reach 1,000,000 tons annually.

[A list of modern sugar factories in the Philippine Islands, compiled at the beginning of 1919 and including both the mills actually in operation and those under construction or definitely planned for construction, may be obtained from the Bureau of Foreign and Domestic Commerce or its district and cooperative offices by referring to file No. 9879.]

[R. S. N.]

The Future of Industrial Alcohols.*

By B. R. Tunison.[1]

Introduction.

To attempt to predict the future of industrial alcohol is similar in many respects to making an attempt to foretell the outcome of a battle in a great war. The phases of the question are so numerous and complex and there are so many interdependent influences involved that any one would presume a great deal who attempted to predict with any degree of definiteness the future of industrial alcohol. However, if present influences are considered, it is possible to anticipate at least a few of the more important developments more or less accurately.

Importance of Alcohol Industrially.

The following statement, made by a joint select committee of Congress in its official report, is fully as true today as it was the day it was made, some twenty years ago.

"The uses of alcohol other than as a beverage are more largely and widely extended than is generally supposed. But while the use of alcohol as a beverage is purely voluntary its employment for all other purposes is legitimate, beneficial, and necessary. No article entering into manufacture or the arts, whether of domestic or foreign production, performs more legitimate or beneficial functions. There is scarcely a manufacturer in the country who does not use alcohol in the production of his goods to a greater or less extent."

Of the various alcohols which have been of industrial importance ethyl alcohol is unquestionably the most important. This alcohol has been subjected to severe trials in the past and burdened by taxes which have caused very great limitations to its legitimate uses. In the industries many costly substitutes have been made because pure ethyl alcohol was obtainable only at prohibitive prices, due to excessive taxes, and because the denatured grades were not suitable for many special purposes.

Production of Ethyl Alcohol.

Raw Material. The considerations which have determined the raw materials to be used in the manufacture of ethyl alcohol have been of a commercial nature rather than essentially chemical. At the present time the state of the art is such that from a chemical standpoint alcohol may be readily produced from nearly any available source of saccharine or starchy materials. To indicate the influence of local commercial conditions on the choice of raw material a few examples may not be out of place.

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*Extracts from article in Journal of Industrial and Engineering Chemistry, April, 1920.
[1] U. S. Industrial Alcohol Co., 27 William Street, New York, N. Y.

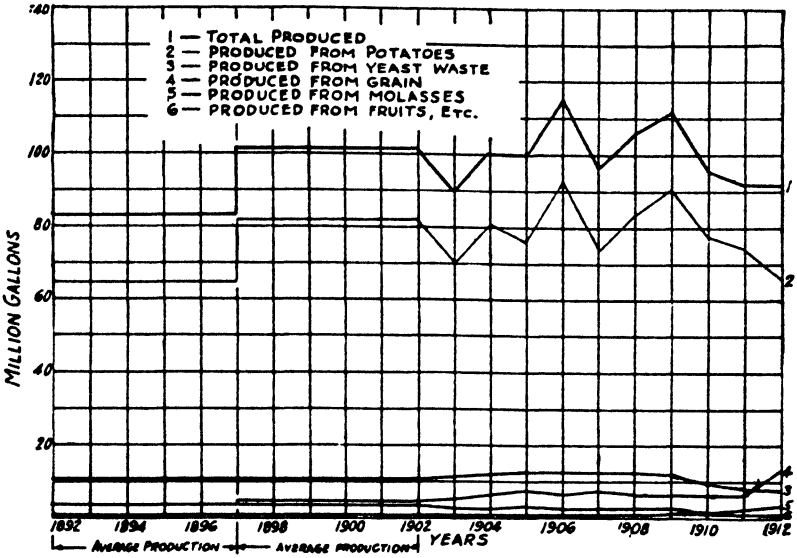

Fig. 1.
Production of Industrial Ethyl Alcohol in Germany, 1892–1912.

In Germany. The production of industrial alcohol in Germany has been a noteworthy example of the industry for some years. The production from the various raw materials is indicated in Table I and Fig. 1.

TABLE I—PRODUCTION OF ALCOHOL IN GERMANY (U. S. GALLONS)

Years	Potato Distilleries	Yeast Distilleries	Grain Distilleries	Molasses Distilleries	Fruit and Other Distilleries
1887/88—1891/92	59,826,000	10,190,000	3,065,000	3,330,000	686,000
1892/93—1896/97	63,362,000	10,370,000	3,615,000	3,620,000	898,000
1897/98—1901/02	81,730,000	10,900,000	4,750,000	3,190,000	872,000
1902/03	70,000,000	11,500,000	4,990,000	2,350,000	502,000
1903/04	80,420,000	12,060,000	6,204,000	4,410,000	608,000
1904/05	75,900,000	12,720,000	7,500,000	285,000	976,000
1905/06	92,820,000	12,670,000	7,000,000	219,000	819,000
1906/07	73,620,000	12,540,000	7,240,000	235,000	792,000
1907/08	83,100,000	12,770,000	6,440,000	272,000	1,005,000
1908/09	90,220,000	11,900,000	6,310,000	229,000	1,267,000
1909/10	77,600,000	9,460,000	6,150,000	1,936,000	1,005,000
1910/11	74,100,000	8,130,000	6,230,000	2,350,000	739,000
1911/12	66,000,000	7,925,000	13,100,000	3,380,000	898,000

Agricultural and labor conditions during the period indicated were such that potatoes were very cheaply produced and the saccharine material obtained therefrom on a per pound basis was relatively cheap, as compared, for example, with grains. Fruits had a higher value as food and the fruit wastes did not occur in

sufficient quantities to materially affect the alcohol production. The molasses available in Germany was largely beet molasses and had a somewhat greater value as a feeding material than as a raw material for alcohol production.

In France. In France sugar beets and beet molasses have been used to a considerable extent as a raw material for production of alcohol. The production from the raw materials used is shown in Table II and Fig. 2.

TABLE II—PRODUCTION OF ALCOHOL IN FRANCE (U. S. GALLONS)

Years	Raw Material			Total	Per Cent of Total Production in France
	Grain Distilleries	Molasses Distilleries	Beet Distilleries		
1908	9,560,000	12,620,000	33,300,000	55,500,000	81.5
1909	9,420,000	12,600,000	20,960,000	52,800,000	82.7
1910	12,200,000	13,350,000	31,200,000	56,800,000	90.0
1911	17,450,000	13,300,000	27,800,000	57,600,000	90.0
1912	23,300,000	12,300,000	42,800,000	78,400,000	89.3
1913	11,340,000	16,000,000	41,200,000	68,600,000	88.0
1914	21,700,000	9,940,000	12,370,000	35,700,000	81.5
1915	9,400,000	6,980,000	21,100,000	38,800,000	74.0
1916	17,560,000	4,100,000	11,900,000	33,600,000	81.6

In Switzerland. Consul W. P. Kent of Berne, Switzerland, has stated[1] that calcium carbide is being developed in Switzerland as a source of alcohol. He stated that installations were started with about 20,000 horsepower minimum and 30,000 horsepower maximum (summer time), which would produce from 7,500 to 10,000 tons of alcohol per annum. Calcium carbide is produced by the usual electric furnace method and acetylene from the calcium carbide by the action of water. Two methods are used in the production of alcohol from the acetylene:

1—Acetylene is hydrogenated by catalytic means and ethylene is produced. The ethylene is dissolved in sulfuric acid, and alcohol and sulfuric acid are formed upon saponification.

2—Acetaldehyde is produced catalytically from the acetylene. The acetaldehyde is oxidized to acetic acid or reduced to alcohol, by means of catalyzers. Great care is used in the selection of a catalyzer in order to eliminate numerous complicated side reactions which are liable to occur.

The production of alcohol by such processes as just described of course necessitates a very cheap source of power. This is available only in such places as Switzerland and Norway, and alcohol made by this means could not compete with alcohol of vegetable origin if such could be produced cheaply in those countries.

In the United States. In the United States many different materials are used with more or less successs. In some portions of the country corn and corn wastes are effectively and economically utilized. These products afford a con-

[1] Commerce Reports, 102 (1917), 426.

venient and easily handled source of alcohol. For many years maize was the chief source of industrial alcohol in the United States, and undoubtedly corn and maize will continue to be a very important source.

Alcohol is being made from waste sulfite liquor in some localities where this waste is obtainable in quantity. Up until the present time the production has not been large enough to materially influence the alcohol market. This is largely due to the fact that there are very few places in the United States where sufficient waste liquor can be obtained to produce more than a few hundred gallons of alcohol per day.

So far as the writer is aware there are but two plants in operation in the United States producing alcohol from sawdust, and these have a relatively small production. There seem to be possibilities in the development of the production of alcohol from wood and wood waste.

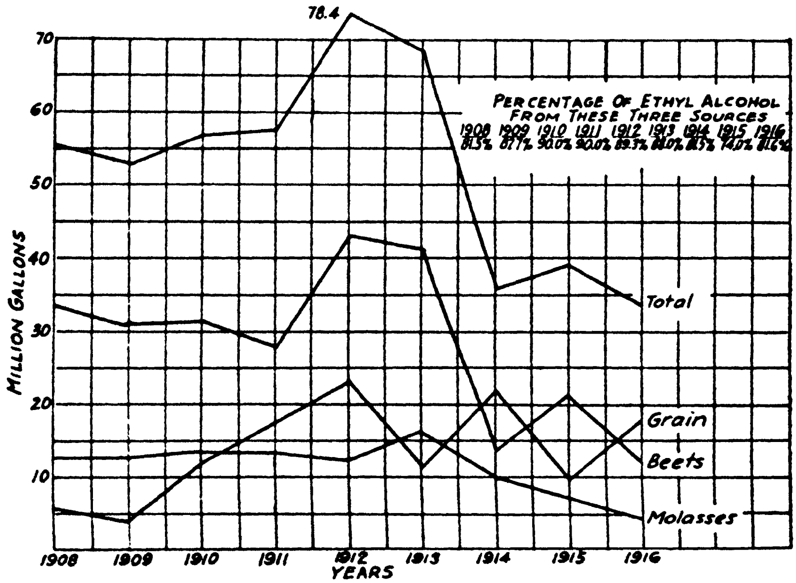

Fig. 2.
Production of Ethyl Alcohol in France.

During the last two years very little alcohol has been produced from the various grains. This is largely due to the fact that the grains are in demand as food materials at a high figure. In this country the only time it is feasible to use grains for the production of industrial alcohol is when a crop has been damaged in some manner so that it cannot be utilized as a food material.

Labor and agricultural conditions have been and are such in this country that potatoes cannot be grown economically enough to compete with trade wastes as sources of alcohol.

Fruit in this country is so valuable as food that it cannot be used as a source of industrial alcohol. Fruit wastes do not occur in sufficient quantity to supply even a centrally located distillery, and transportation of such products is of course not feasible.

TABLE III—RAW MATERIALS FOR PRODUCTION OF ALCOHOL IN THE UNITED STATES

States and Territories	Raw Materials						Total	
	Corn Bu.	Rye Bu.	Malt Bu.	Other Materials Bu.	Molasses Gal.	Sulfite Liquors Gal.	Bu.	Gal.
California	1,656	....	....	....	13,223,826	....	1,656	13,223,826
Connecticut ...	1,767	1,622	1,311	....	....	....	4,700	....
Dist. Columbia	79,309	....	122,013	69,909	236,433	....	271,231	236,433
Hawaii	....	....	....	....	7,700	....	....	7,700
Illinois	8,130,912	29,770	880,135	44,993	4,219,519	....	9,085,810	4,219,519
Indiana	2,637,875	48,036	206,883	50,942	....	....	2,943,736	....
Kentucky	2,200,183	87,771	282,019	36	226,980	....	2,570,009	226,980
Louisiana	9,594	132	1,000	2,986	33,214,705	17,620,539	13,712	50,835,244
Maryland	130,522	2,734	5,176	....	34,626,539	....	138,432	34,626,539
Massachusetts.	2,690	2,418	1,272	....	13,118,139	....	6,380	13,118,139
Michigan	....	....	....	....	....	5,290,164	....	5,290,164
Missouri	13,967	1,986	2,444	....	....	....	18,397	....
Montana	....	....	....	....	249,340	....	....	245,340
New York	342,150	37,712	69,158	....	11,025,740	28,637,832	449,020	39,663,572
Ohio	578,451	3,170	63,324	784	....	....	645,729	....
Pennsylvania..	295,793	7,116	33,213	....	7,873,097	....	363,122	7,873,097
Rhode Island..	....	....	....	7	5,942	....	7	5,942
South Carolina	....	....	....	2,382	....	16,958,609	2,382	16,958,609
Texas	....	....	....	....	....	20,098	....	20,098
Wisconsin	119,676	26,397	21,729	....	....	....	167,802	....
Total	14,544,545	248,864	1,689,677	172,039	118,027,960	68,527,242	16,665,124	186,555,202
Total for Fiscal Year 1917 ..	33,973,268	3,375,439	4,239,677	81,435	112,497,633	78,462,969	40,669,819	190,960,602

SUMMARY.

	Gal.
1913	193,606,258
1914	181,919,542
1915	140,656,103
1916	253,283,273

Sugar beets and beet molasses have not been used to any extent for the production of industrial alcohol in this country, because at present they are utilized for feeding purposes and they cannot compete with other trade wastes.

The chief source of industrial alcohol in the United States is cane, or black strap, molasses. Only a few years ago, especially in the East and West Indies, the disposal of molasses by the sugar mills was a serious trade waste problem, but it is now very largely used the world over as a raw material for alcohol manufacture. The conversion of molasses into alcoholic liquor, especially into rum, is an old enterprise. West India rum has been famous in New England for more than 200 years. But the use of molasses in large quantities for industrial alcohol production is a development of the last few years. As far as ease of manipulation is concerned, molasses unquestionably surpasses any other

known material. Moreover in the past it has been a very cheap material. A large portion of the world's molasses is still a waste product due to the difficulty and expense of transportation to the commercial centers.

Molasses from Cuba and Porto Rico is of special importance to the United States, because of the several million tons which are annually available for the production of alcohol. This molasses is gathered from the various producing mills in barges, steam lighters, hundreds of tank cars, and in some few cases barrels and hogsheads, and taken to the large storage tanks which are located at deep water shipping ports. Tank steamers, such as are used for the transportation of petroleum, are used to carry the molasses from these storage points to various plants in the United States: in Boston, New York, Baltimore, New

TABLE IV—PRODUCTION OF ALCOHOL IN THE UNITED STATES

States and Territories	1918			1917
	From Materials other than Fruit—Gal.	Fruit Brandy Gal.	Total Production Gal.	Total Production Gal.
California	8,727,694	5,295,952	14,023,646	17,851,482
Connecticut	23,527	2,924	26,451	132,055
District of Columbia	749,517	....	749,517	608,812
Hawaii	3,935	....	3,935	14,016
Illinois	49,679,940	140	49,680,080	79,320,617
Indiana	15,820,031	10,899	15,830,930	43,361,276
Kentucky	12,604,703	3,734	12,608,437	36,441,778
Louisiana	24,406,539	....	24,406,539	26,545,832
Maryland	26,746,386	....	26,746,386	24,965,321
Massachusetts	10,873,375	....	10,873,375	12,511,238
Michigan	752,745	....	752,745	819,908
Missouri	77,026	2,501	79,527	289,661
Montana	186,248	....	186,248	244,773
Nebraska	....	....	....	2,938,594
New Jersey	....	51	51	54,494
New Mexico	....	....	....	315
New York	10,540,421	4,480	10,544,901	13,856,054
Ohio	3,277,485	36,618	3,314,103	10,114,573
Pennsylvania	7,293,914	....	7,293,914	12,190,764
Rhode Island	2,845	....	2,845	224
South Carolina	943,568	....	943,568	1,159,309
Texas	7,281	....	7,281	13,905
Virginia	....	....	....	122,957
Wisconsin	759,294	....	759,294	2,527,249
Wyoming	....	26	26	260
Total	173,476,474	5,357,325	178,833,799	286,085,464

Orleans, and other points. In addition to the above-mentioned sources of molasses large quantities are obtained from the cane sugar refineries located in the southern and southeastern parts of the United States.

The various raw materials used and the quantities of alcohol obtained from them are indicated in Tables III and IV.

The figures are, of course, totals and include the beverage alcohol production.

The total production of ethyl alcohol in various countries from 1908 to 1912 is shown graphically in Fig. 3.

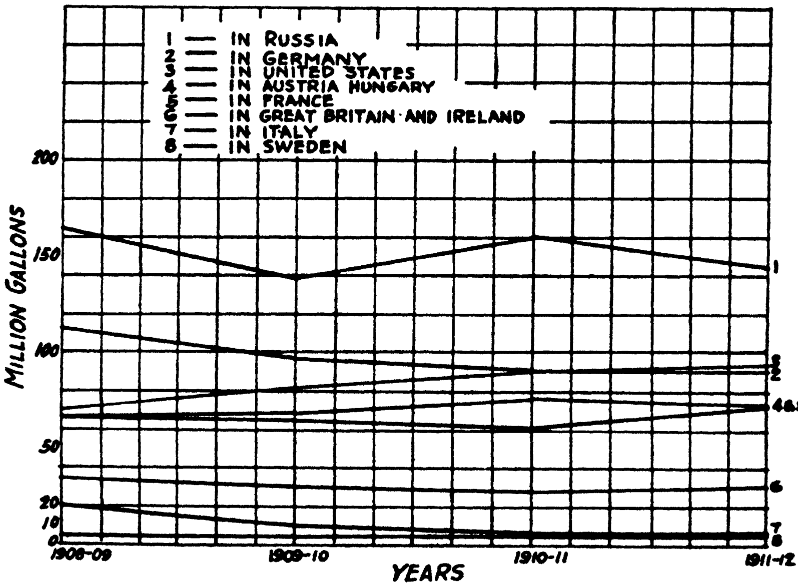

Fig. 3.
Production of Ethyl Alcohol, 1908-1912.

PRODUCTION OF DENATURED ALCOHOL.

In the last few years the production and consumption of denatured alcohol in the United States has increased very greatly, as shown by Table V and Fig. 4.

TABLE V—PRODUCTION OF DENATURED ALCOHOL IN THE UNITED STATES

Fiscal Years	Denaturing Warehouses	Completely Denatured Wine Gal.	Specially Denatured Wine Gal.	Total Wine Gal.	Total Proof Gal.
1907	8	1,397,861	382,415	1,780,276	3,084,950
1908	12	1,812,122	1,509,329	3,321,451	5,640,331
1909	12	2,370,839	2,185,579	4,556,418	7,967,736
1910	12	3,076,924	3,002,102	6,079,027	10,605,870
1911	14	3,374,019	3,507,109	6,881,129	11,682,887
1912	14	4,161,268	3,933,246	8,094,515	13,955,903
1913	21	5,233,240	4,608,417	9,831,658	16,953,552
1914	25	5,213,129	5,191,846	10,404,975	17,811,078
1915	23	5,386,646	8,599,821	13,986,468	25,411,718
1916	33	7,871,952	38,807,153	46,679,108	84,532,253
1917	44	10,508,919	45,170,678	55,679,597	93,762,422
1918	49	10,328,454	39,834,561	50,163,016	90,644,722

The falling off in the quantity of denatured alcohol used during 1918 is accounted for by the fact that in the early part of the year several of the larger munition plants discontinued the manufacture of explosives for the Allies, in which denatured alcohol had been used, and engaged in the manufacture of explosives for the United States Government, using principally tax-free undena-

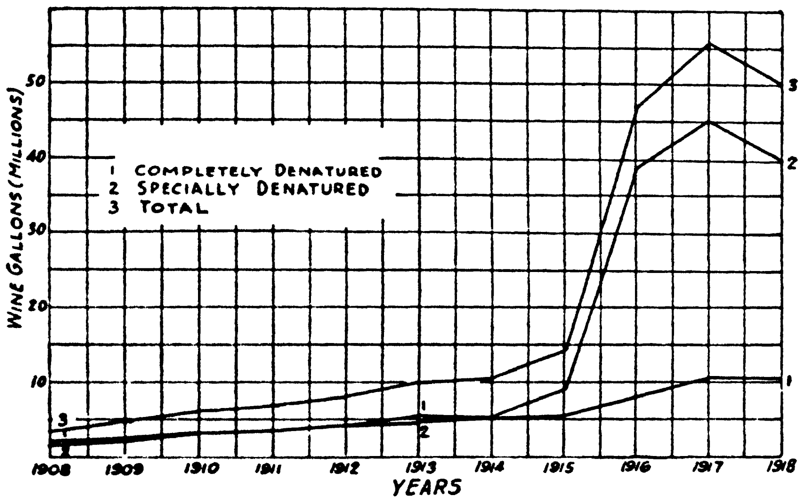

Fig. 4.
Production of Denatured Alcohol in the United States.

tured alcohol. The army specifications were subsequently changed and denatured alcohol was used exclusively in those plants. The quantity of denatured alcohol used during the year in the manufacture of explosives and for other war purposes was approximately 52,847,117 proof gallons.

Manufacture From Raw Materials.

The alcohol industry as it stands today is the result of a very long period of development. The methods and apparatus used have become pretty well standardized and no revolutionary changes or developments are anticipated. Many minor improvements are being made from time to time, but as far as the distillation and rectification are concerned the principles involved have been carefully worked out and apparatus designed which correctly applies them.

A large amount of research is being directed towards the processes of fermentation and we may hope for many developments from this phase of the industry. Paralleling this development, better systems of plant control will undoubtedly be put into practice. While the yields obtained at present are good, better results are being searched for.

Uses of Industrial Alcohol.

As far as the influence of the industries in which alcohol is used is concerned, the use of alcohol in the future should develop fully as rapidly as the industries themselves. If this were the only, or even the most important factor, as it is concerning most commodities, the prediction of the future would be a relatively simple matter. Most of the newly developed chemical industries in this country have come to stay and they will require an ever-increasing quantity of alcohol.

While most of the uses of alcohol will be developed more or less parallel with the development of the chemical and allied industries, there are a few the expansion of which will be more or less revolutionary in character.

Solidified Alcohol. One of the very important uses today, and one that is becoming increasingly so, is that of solidified alcohol. Alcohol burns with a smokeless flame and does not carbonize like kerosene, so that even at the present time it is a very satisfactory fuel, and its only rival for chafing dishes, coffee percolators and such articles is electricity. In regions where electricity is not available solidified alcohol is a very important fuel for cooking purposes. It is also used very extensively during vacation trips to the mountains or the seashore. It is very convenient to handle and is without dirt, smoke, or odor, and is an economical fuel, and undoubtedly the use of alcohol in this form will increase to a very marked degree.

Purification of Turpentine. One of the newer developments is the utilization of alcohol in the separation and purification of gum-turpentine. The present method of heating and making the crude products at the turpentine camps results in rosin of which only a small part is of good color. It has been found that the crude gum-turpentine is readily soluble in high proof denatured alcohol. It is then possible to remove such foreign matter as particles of wood, twigs, insects, etc., which have been found largely responsible for coloring the finished products. Subsequent distillation of the gum-turpentine-alcohol solution results in a separation of the alcohol heads containing a small percentage of turpentine, which functions as a denaturant and at the same time produces a product which can be used again as a solvent. The turpentine fraction is clear and marketable as a high-grade product and the rosin residue is colorless and of the highest

grade. The loss of solvent at present is approximately 6 per cent and developments indicate that it may become lower. When using this process it is possible to centralize the processing of the gum-turpentine and thus reduce operating expense to a minimum. The increase in quantity of high-grade products, the very small losses involved, and the small cost of operation incurred by this process indicate that it will become of very great importance in the turpentine industry.

Ethylene. Another relatively new development in the utilization of alcohol is in the catalytic production of ethylene. Ethylene has been considered as a substitute for a cutting and welding gas in the place of acetylene. From comparative tests ethylene is found to have many advantages over acetylene. As far as the heat of combustion is concerned ethylene has a slightly higher value. In cutting and welding iron and steel ethylene has among others the following advantages:

1—It has a high ratio of carbon to deterrent element like hydrogen, overcoming the tendency to retard combustion and slow the cutting.

2—It has a rapid rate of combustion, preventing loss of temperature from absorption and conduction of heat by the metal being cut.

3—It will help to maintain an oxidizing effect fast enough to overcome any tendency to burn too deeply or chill the surfaces of the metal being cut.

4—It will produce a rapid rate of cutting with a low consumption of gas, making a high efficiency possible from the regular operators of the torch.

5—It shows a decrease of labor and gas consumption with increase of thickness of metal cut, making the cutting of thick metal as economical as thin metal.

6—It possesses a remarkable degree of lightness of the charged cylinders, providing a valuable portability and ease of movement of the gas supply about a shop.

7—It is a non-poisonous, safe gas, without objectionable odor.

8—It has a clearly outlined cone in the flame, without which a workman would be badly handicapped.

In the working of copper it has been impossible to make a satisfactory weld with acetylene, because of the formation of carbon and the consequent blistering in the weld. Perfect copper welds have been obtained with ethylene.

In aluminum welding and lead burning ethylene is infinitely better than acetylene. There is no carbon formation and no kick back in the burner, while a terrific heat may be maintained.

It is a much safer gas to handle, since it does not explode spontaneously. It can be compressed and handled in the standard form of gas cylinder without either packing or a solvent (acetone). For this reason it is possible to make a saving of about one-half in the cost of the cylinders and approximately one-half in the freight cost. Furthermore, ethylene can be compressed so that a cylinder will hold over 200 cu. ft. of ethylene. Thus the cost per cubic foot for shipment is again cut in half. Ethylene is essentially a "one man" gas. The weight of ethylene per 100 cu. ft., including the container, is only 40 lbs., as compared to 90 lbs. for acetylene. A cylinder of ethylene weighing between 80 and 85 lbs. contains approximately 210 cu. ft. of gas and can be easily handled by one man.

Ethylene is being sold at the same price as acetylene. It may be used in an ordinary welding torch, but preferably one with a mixing chamber. A change in the size of the tip is also desirable.

In addition to the use of ethylene as a cutting and welding gas it has been found to have considerable value for lighting and heating purposes where electricity is not available.

In the chemical industries we all realize that with a source of cheap, pure ethylene it will be possible to manufacture a great number of synthetic and chemical products.

Internal Combustion Engines. Probably the use of alcohol which in the future will have the greatest significance is its use as such, or in admixture with other compounds, as a fuel for internal combustion engines. For years volumes have been written about the use of alcohol in such engines. In Germany, where the supply of petroleum products was inadequate and where alcohol was a relatively cheap commodity, large quantities were used for automotive and power purposes. In France alcohol was used extensively for automotive engines. In the United States considerable has been said about using alcohol for automobiles, farm machinery, etc. Vivid word pictures have been drawn of the farmers taking their waste products and processing them in their small plants and then doing everything from sawing wood to doing the family washing with alcohol as a source of power. However, the petroleum supplies in this country have been so abundant and available at such reasonable prices that these word pictures have remained as such and the farmers continue to buy gasoline with which to operate their automobiles and small engines. This has been the case since the agitation for alcohol production by the farmers in 1906–7.

Recently, however, conditions have suddenly changed. The Geological Survey tells us that in about three years the peak in a curve showing petroleum production will be reached and after that time there will be a gradual decline in petroleum production over a long period of years.

Not only will the production of petroleum continually decrease, but the present indications are that the demand for petroleum products will increase in the next few years even more rapidly than ever. The increase in the number of automobiles, trucks, tractors, and airplanes during the last five years has been remarkable. If the increase from now on is only a small percentage of what it has been we must soon obtain a new supply of explosion engine fuel, and while our supply of petroleum is limited in quantity, the raw materials for the production of alcohol are around about us in inexhaustible quantities. At this time the utilization of alcohol for power purposes appears very significant.

While it will probably be several years before alcohol alone will be used as a motor fuel, alcohol in admixture with other fuels is now being produced and marketed in some localities of this country. The alcohol fuels as used at present do not require a specially designed engine to obtain optimum results, but the standard engine and accessories are used with excellent results. Alcohol fuels have many advantages over gasoline when used in automotive engines, some of which may be summarized as follows:

Greater mileage;
No preignition;

No knocking;
More uniform application of power during power stroke of piston;
More power;
Power more completely under control.

Even though the alcohol has a lower B. t. u. value for the heat of combustion, the combustion of the fuel is more complete and greater efficiencies are obtained. This is especially true in slow speed engines such as motor trucks.

Alcohol fuels have also been developed for airplane use. In this regard the Journal of the Society of Automotive Engineers[1] says in part:

A new alcoholic fuel, consisting of alcohol, benzol, and ether, is about to take the place of the high-grade airplane gasoline, which has previously been used in the Air Mail Service.

The advantage of this fuel lies in the resulting cleanliness of the engines, reduction in the cost of upkeep and its burning cooler than gasoline, which to some extent overcomes the objection to a high-compression engine when operating at low altitudes. It requires about four-fifths as much of the new fuel for any given distance and altitude. This gives greater flying radius to the planes and will enable the DeHaviland Fours to cover the New York to Cleveland route, a distance of 430 miles, in a non-stop flight. It reduces the probability of forced landings by keeping the spark plugs and the engine cylinders clear of carbon deposits and accumulations of oil.

As the realization of the advantages of the above-mentioned fuels becomes more universal, and as the quality of the gasoline becomes poorer due to the diminishing petroleum supply, and as the price of gasoline rises, alcohol will be used in greater and greater quantities. In anticipation of this great increase in the demand for alcohol for power purposes we should take active steps to assist in the development of the alcohol industry so that an adequate supply of alcohol may be at hand when needed.

Probable Effect of Legislation on the Future of Industrial Alcohol.

The effect of the passage of the industrial alcohol bill in 1906 had a marked effect on American industries in which alcohol is used. Many new enterprises were undertaken and those in operation were greatly extended. Since 1907 these industries using alcohol have prospered and grown until the United States, instead of being one of the smallest nations from an industrial alcohol point of view, has now become one of the greatest world influences. The increase in the production of industrial alcohol since 1907 is summarized in the last two columns of Table V.

While the progress made by the alcohol industry has been little short of remarkable, our chemical industries which depend very largely on a supply of cheap alcohol have not prospered as have those in some other countries. The bill of 1906 was an important step forward, but the manufacture, sale, distribution, and use of alcohol was so surrounded with rules and regulations that many manufacturers did not use it and the normal growth of the industry was never approximated.

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[1] Journal of the Society of Automotive Engineers, 5 (1919), 207.

When the present prohibition bill was being discussed and prepared the very existence of the industries using industrial alcohol was threatened. The Commissioner of Internal Revenue, with very great foresight and with a realization of the necessity of a supply of alcohol for industrial purposes, the use of which should be as free of restrictions as possible, prepared and presented the section of the prohibition bill relating to industrial alcohol. The assistance given by the Internal Revenue Bureau in showing the necessity of industrial alcohol, and the absolute dependence of some industries on a supply of alcohol, to those concerned with the making of our laws was a cooperation with the chemical and allied industries which should be known and appreciated by every chemist. A great deal of credit should be given to members of the present Congress who took time to learn facts concerning some of the industrial phases of the alcohol question, with the result that the industrial alcohol section of the bill was passed.

Now that a new law is to govern the alcohol industry we may feel certain that the Internal Revenue Bureau will proceed in the same manner in drafting the rules and regulations which are to surround the manufacture, sale, distribution, and use of alcohol. We may feel confident that the Government's taxable interests will be protected and at the same time the manufacturers will be given the greatest possible freedom in the use of alcohol for industrial purposes. Due to the attitude of fairness of the Internal Revenue Bureau, it is not too much to expect that we shall have alcohol under such conditions as will be an added stimulus to the progress of our rapidly growing chemical industries.

Aside from the natural growth of the alcohol industry care should be taken to foster its development. We are told that we should maintain a policy of preparedness throughout the coming years. Now that the whiskey distillery is to be a thing of the past, where could we look for a supply of alcohol in case of war? In the recent war the distilleries came to the rescue, and in case of another war we must have industrial alcohol plants in operation which could immediately supply large quantities of a most necessary product.

It has been said that the future increased production of alcohol could be attained by persuading the farmers to produce alcohol in small agricultural distilleries in a manner similar to those in operation in Germany. There are several reasons why this is not likely to take place. Labor is very much higher in this country than in Germany. The farmers of this country have become accustomed to production on an extensive scale rather than in an intensive manner, and are not likely to be satisfied with the results of a small distillery. In order to obtain satisfactory results the fermentation must be carefully controlled, and the average farmer does not possess sufficient technical training to do this effectively. The manipulation of an alcohol plant is difficult except to a technical man. These farm installations would necessarily be small units because of the limited quantity of raw material available, the cost of the installation would be high, the labor cost would be excessive, the output would be small, and the unit cost of production would be so high that the farmer could buy alcohol cheaper than he could make it. Our case is quite different from that of Germany, where these conditions do not exist, and where the industry has been subsidized by the gov-

ernment. Without such subsidy and government pressure it is the writer's opinion that the farmers of this country are not likely to produce alcohol for industrial purposes for some time.

Alcohol is essentially a cheap commodity and should be treated as such. Today this is not the case, and the manufacturer may be partly to blame for this condition. If manufacturers using alcohol in quantity would buy alcohol as they buy other commodities in tank car lots and not require shipment in expensive cooperage or steel drums, they would help to remove the impression that alcohol is such a valuable product. The ordering, billing, shipping, returning, crediting, etc., of these packages is a nuisance as well as a source of considerable expense. Alcohol is the only product in the history of the United States which has been taxed several hundred per cent of its value. This has given the impression that industrial alcohol is also extremely valuable. As the uses of alcohol are developed and as it becomes used more extensively for such purposes as motor fuel, it is not too much to expect that it should be handled in much the same manner as petroleum and its products. Great Britain is beginning to realize that alcohol is essentially a cheap product and should be treated as such. The British Inter-Departmental Committee on the Production and Utilization of "Power Alcohol" recommends in part the following:

> As the price of alcohol for power and traction purposes, to which we propose the name of "power alcohol" should be given, must be such as to enable it to compete with gasoline, it is essential that all restrictions concerning its manufacture, storage, transport, and distribution should be removed so far as possible, consistent with safeguarding the revenue and preventing improper use, and that cheap denaturing should be facilitated.
>
> Finally, we are of opinion that steps to facilitate the production and utilization of power alcohol in the United Kingdom can in no circumstances be taken, nor arrangements for such development carried into effect, unless provisions and alterations of the kind we recommend in our report are made in *advance* of the time when an acute recurrence of high prices for motor fuels may otherwise call for action too late for it to be effective.

Why should not the common carriers in this country as well as our Government recognize that industrial alcohol is a 50-cent commodity and not one of $5.00 value? Why shouldn't manufacturers assist in bringing about such a recognition by using the specially denatured alcohols wherever possible and not be frightened by such words as "permit," "bond," and similar words identified with the Internal Revenue Bureau. The Commissioner of Internal Revenue is the friend of the manufacturer using alcohol and not his enemy. He will endeavor to assist you and not retard your progress. Over forty formulas of specially denatured alcohol have been authorized for use in the manufacture of over 350 articles in addition to many class authorizations. The Commissioner of Internal Revenue will consider the authorization and the extension of the use of any formula in new industries or will consider the authorization of new formulas, if existing formulas are not applicable. As long as the Government's taxable interests in the alcohol are protected it may be freely used by the industries.

The requirements of the Internal Revenue Bureau surrounding the use of specially denatured alcohol are neither difficult nor prohibitive. The papers may

be easily prepared. If you are a user of alcohol why shouldn't you take advantage of your privileges and assist in the stabilization and progress of our American chemical industries?

If the United States builds up a large industrial alcohol production and fosters its growth and development the industries will benefit, and there is no question but that this nation as a world power will be stronger. During peace the nation will be strong because of its industries; during war these industries using alcohol will be instantly available as the media for the production of war materials.

CONCLUSIONS.

In the preceding paragraphs it has been possible to mention only a few of the probable influences affecting the future of industrial alcohols, and to attempt to indicate in a general manner their effect on the future. Now that the realization of the necessity of industrial alcohol is becoming more general, legislation favorable to manufacturers is taking place and the industries using alcohols are developing rapidly. May we not look forward to the time when the industry of making industrial alcohols in the United States will be of such magnitude as to be a great national asset under all conditions? [R. S. N.]

THE HAWAIIAN PLANTERS' RECORD

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A monthly paper devoted to the sugar interests of Hawaii and issued by the Experiment Station for circulation among the Plantations of the Hawaiian Sugar Planters' Association.

The Short Course for Plantation Men.

The University of Hawaii and this Experiment Station have been asked to conduct another Short Course this year. Plans are now under way with this end in view.

The two weeks course will begin Monday, October 11, and end Saturday, October 23. It will be modelled upon the 1919 session, with such changes and improvements as may be advisable. Essentially the same ground will be covered as at the former session.

The success of last year's short course was due largely to those who attended the course and took such active interest in the work under way. Twenty-eight plantations and two Honolulu agencies had representatives in attendance. The twenty-eight plantations sending representatives were divided among the different islands of the group as follows:

15	plantations	on	Hawaii
4	"	"	Maui
4	"	"	Kauai
5	"	"	Oahu

The course is designed to give those who attend a clearer understanding of many of the questions pertaining to sugar production.

There will be lectures, demonstrations, and discussions. There will be no examinations or quizzes.

Insect pests, sugar cane diseases, fertilizers and fertilization, irrigation, cane varieties, cultivations, and watershed forests, are among the subjects to receive attention.

The same liberal support as previously on the part of the plantations in sending their field men to Honolulu for the two weeks course is again needed to make this undertaking the benefit it should be to all concerned.

Trees and Plants as an Aid to Plantation Improvement.

Industrial Service Bureau, H. S. P. A.

Line of laborers' quarters well planned on Maui.

Pleasantly situated Portuguese quarters on a Kauai plantation.

Trees and palms improve the appearance of a mill.

Improvements in mill yards are well worth while.

The Fundamentals of High Mill Extraction.

By A Mill Engineer.

The following paper, under the heading of "A Few Hints to Young Engineers on High Extraction," was originally intended for presentation at the 1918 conference of mill engineers in Honolulu. As there was no conference either in 1918 or 1919, the paper was not published. At the urgent request of a friend the writer now submits this paper for publication. The usual method of treating a paper on milling is to describe the machinery in use, and the advantage or disadvantage of each and every process the cane is subjected to, from carrier to fire room.

The writer is particularly anxious to avoid boosting any one make of machinery, and equally so of knocking any other make. It is his desire to treat the subject from an entirely unbiased viewpoint, with the intention that the following remarks may be applicable to any mill in the Hawaiian Islands, irrespective of the quality or make of machinery in use.

The preparatory machinery, that is the machinery used for preparing the cane for the first mill, should by rights have first call on our attention, but, for the reasons given above, the writer does not intend to go into detail in this branch of the subject.

As a matter of fact, the importance of preparatory machinery has been greatly overrated of late years, and consequently this branch of milling has received more attention than it merits. The writer, however, will commit himself so far as to say that it is very important that the cane be well prepared on entering the first mill. The better it is prepared, the easier it will be to obtain good results in the process of crushing.

Hydraulic Pressure.

As the fundamental principle of milling is the extraction of the juice from the cane by means of pressure, it is the opinion of the writer that the point of primary importance in high class mill work is the proper and effective application of that pressure.

Theoretically there is no limit as to the amount of weight that should be carried on a mill, but in practice the operator has to be governed by local conditions and the strength or quality of the equipment at his disposal. Poor equipment or unfavorable local conditions should not be made the excuse for poor mill work, however. It is the duty of the engineer to overcome adverse conditions and to strive for the best results with the machinery at his disposal.

Only good judgment, tempered by experience on the part of the engineer in charge, can determine the correct amount of weight to carry on a mill. It should be his aim, as high pressure is essential to high extraction, to carry the highest safe working load possible. Roughly speaking, from 70 to 80 tons per lineal foot of roller may be considered good practice.

The writer believes that a word of warning against excessive loading will

not be out of place here. The tendency of operators of late years has been to ignore the factor of safety altogether, load up the mills until something breaks, have the broken part replaced by a stronger part, and so go ahead again. This method of working may be conducive to high extraction, but it certainly is not good engineering practice.

In some factories the engine capacity, or rather the lack of sufficient engine capacity, is the determining factor as to the amount of weight to be carried on the mills. The rectification of conditions of this kind is specifically an engineering problem, and although very interesting, it cannot be gone into in this paper.

It is of the utmost importance in good mill work that the total weight, i. e., the weight applied by the hydraulic jacks plus the weight of the top roller, be utilized to the best advantage. As much as possible of this weight should take effect on the blanket of bagasse passing through the mill. Any weight taken up by the driving pinions, top roller brasses, or the returner bar, is so much waste, so far as useful work is concerned, and should be eliminated as far as possible.

Size and Position of Hydraulic Jacks.

With regard to unequal pressures on different mills, the safe working load for one mill is equally the safe working load for another mill of the same size and make. The only instance where it may be necessary to carry unequal loads is in the event of insufficient engine capacity, and then only when the preparatory machinery is not doing good enough work; then it may possibly be advantageous to reduce the weight on the second and third mills to enable the full pressure to be carried on the first mill.

A top roller is always inclined to ride on the pinion end, due to the action of the driving pinions, and in a mill where the jacks are the same size on both ends of the roller, a higher moisture on the pinion end will be the result. To eliminate this a larger jack should be installed on the pinion end. The operator should remember, however, that this larger jack is provided as a precaution and is no prevention in the event of badly fitting pinions. The mere fact that it is necessary should be sufficient proof that the driving pinions must at all times be kept in good order. The pinions should be of correct size, properly meshed, and always well lubricated. It is very important that the top roller brasses be in good order; neglect or carelessness in fitting may mean a great decrease in efficiency. Some means of offsetting the hydraulic jacks should be provided. This offset is necessary to prevent the brasses from tilting up on the feed side and becoming wedged in the housing. The amount of offset necessary to keep the brasses fairly level will vary in different mills, but as a general rule it will be found that about one inch offset in the first mill, gradually decreasing to about five-eighths inch in the last mill, will be sufficient.

Effective Use of Hydraulic Pressure.

The brasses should be an easy working fit in the housing, and the faces in contact with the housing should be generously supplied with oil grooves and kept well lubricated.

A few years ago it was a common practice to fit shims below the top brasses, with the idea of releasing the pressure on the top roller when the mill was running idle. Just why this was deemed necessary the writer is unable to say. The result in the majority of cases was that when the mill received the feed the top brass would lift on the feed side only, and a great deal of pressure supposed to be taking effect on the top roller was in reality being applied through the shims to the mill cheek. This possibility should be entirely done away with; the top roller brasses with full pressure applied should be at least one-quarter inch clear of the mill cheek on both feed and bagasse sides. By adopting this method the full pressure is bearing on the top roller at all times, and it is only necessary for the roller to lift the merest fraction to assure the full pressure being transferred to the blanket of bagasse passing through. Setting the returner bar too high is another cause for the loss in pressure applied, sometimes overlooked by operators. The proper method of setting returner bars will be gone into a little later in this paper; it is sufficient for the present to remind operators that the returner bar is designed purely for carrying the blanket from the feed to the bagasse rollers. It cannot under any circumstances extract juice, therefore, any undue strain applied to it is so much waste.

Another source of loss is in the driving coupling on the top roller. But if the operator has assured himself that the mill is properly lined up and that the coupling is of sufficient size, he has done all that is possible in eliminating this loss. Although pressure is such an important factor in obtaining high class mill work, it should be understood that all other conditions must be favorable before high pressure can be profitably applied. It is quite possibie to overload a mill under adverse conditions with a pressure of only 50 tons per lineal foot. This does not necessarily mean that the mill is working under a weight that cannot be safely carried by the rollers.

Slippage.

The term "overloading," as used in connection with milling, simply means that the blanket of bagasse passing through the mill is for some reason incapable of lifting and keeping in suspense the top roller Choking, that is refusing the feed, is always the result of overloading, and this is caused not by the feed and top rollers, but by a slipping of the bagasse and top rollers. Again I want to emphasize that, if high extraction is desired, the remedy is not in reducing the weight, but in rectifying deficiencies in the equipment. To get the best results it is necessary that the blanket should enter the feed of uniform thickness, continue over the returner bar, and pass out at the discharge at the same speed as the surface of the top roller. In other words, there should be no tendency of the top roller to slip past the blanket. Slip always means that the blanket is being broken, and pockets of juice are formed and carried through with the bagasse, which, it can be readily understood, is fatal to high extraction.

As the prevention of any tendency to slip is of so much importance, it is always advisable to surface groove the rollers. The surface grooves should not be any larger than is necessary for the purpose for which they are provided, five to eight grooves per inch being considered good practice. When a very

large tonnage ratio is desired it is sometimes necessary to have large or coarse grooving all through the train of mills; but it must be understood, eliminating the question of higher tonnage, that increasing the size of the surface grooves increases the drainage resistance, thereby decreasing the possibility of the juice being extracted.

Juice Grooves.

It is the fact of cutting down the drainage resistance that makes the juice grooves of so much value. Juice grooves do not extract juice, they merely facilitate in the escape of juice that has already been extracted.

There is great difference of opinion as to the proper width, depth and pitch of juice grooves. The writer does not see why there should be much room for argument on this subject. It is obvious that the width should be as small as possible, the depth large enough to take care of all the juice, and they should be spaced as closely as mechanical reasons will permit. Grooves one-eighth inch wide by one and one-quarter inches or one and one-half inches deep, not more than two inches apart, are what the writer would recommend. It is absolutely essential that these juice grooves be kept clean; if one set of scrapers is not sufficient to do this, two sets should be provided.

Returner Bar Setting.

The setting of the returner bar has a great influence on the correct feeding of a mill. A returner bar set too high causes slipping and choking between the feed and top rollers, as well as unnecessary friction and waste of pressure on the bar itself. The general tendency, however, is to set the bar too low. Although the friction may be reduced by low settings and the mill may run more quietly, that is with less groan, this does not mean that it is doing better work; in all probability it is not doing such good work. The writer rather likes to hear a mill groan a little; it is an indication that it is "on the job."

It is the opinion of some operators that the top roller is responsible for carrying or dragging the blanket over the bar. This is an entirely mistaken idea, although a well roughed top roller does assist to some little extent. The pushing force of the blanket leaving the feed is the principal factor, however.

If the bar is set too low, that is if the space between the top roller and the bar is too large, the blanket passing through will pile up against the discharge roller until the space is packed full before the discharge roller will start to feed. This simply means that the blanket passing over the bar is thicker than the blanket being discharged from the mill; therefore it must be moving slower than the surface of the top roller. In other words, the top roller is slipping over the blanket on the returner bar. Now, as the blanket being pressed against the bagasse roller is thicker than the blanket leaving the mill, the bagasse roller has also to slip past so much of this blanket to assure a uniform feed in the discharge rollers. Unfortunately, however, for this style of setting, the bagasse roller does not always slip just the required amount. As a matter of fact, the discharge rollers generally take a large and small bite alternately, and in this way have a tendency to break up the blanket and leave pockets of juice. A mill

under these conditions is often incorrectly assumed to be doing fine work, because the accumulator weights keep jumping up and down all the time. A returner bar set with too large an increase of opening from toe to heel, i. e., with too low a heel, has exactly the same effect on the discharge rollers.

When a bar is set properly the blanket should travel over it at the same speed as the surface of the top roller and should enter the discharge without any tendency to pile up against the bagasse roller. For the proper setting of a returner bar the operator has to be governed by the speed of the mill, the tons of cane ground per hour, and the per cent fiber in the cane. In theory the bar should be set concentric with the top roller, but this method, owing to the enormous friction, is not practical. The correct method is to allow a slightly increased opening from toe to heel. This increase or clearance should not be more than one-half inch. To insure the correct amount of clearance at all times, it is necessary that the bar toe and holder move forward bodily and in accordance with the amount of wear of the toe on the feedroller. As this is not practical in the common style of returner bar, a good method is to move the bottom of the bar holder forward by means of the adjusting screws at the end of each week's run a sufficient amount to correspond to the wear on the toe of the bar for that week — say one-eighth inch when the bar is new to one-sixteenth inch or one-thirty-second inch after the mill has been running a few weeks and the toe has a fairly large wearing surface.

It is well to remember that a bar set concentric with the top roller does not wear so quickly on the toe as does a bar set with an increased opening from toe to heel. The greater friction of the bagasse passing over the concentric set bar serves to pull it away from the feed roller, but again the greater the friction, correspondingly greater will be the strain on the returner bar bolts and the more difficulty there will be in keeping the feed roller clean.

To curtail this friction and consequently help the working of the mill, the bar should be no wider than is absolutely necessary, which simply means that the centers of the bottom rollers should be as close together as it is possible to get them.

The distance from the heel of the bar to the bagasse roller should not be too great — one-quarter inch is quite sufficient if the bar is set properly. The following rule to determine the height of a returner bar, although not absolutely correct, may be applied with good results in the majority of cases. The distance from the surface of the top roller to the center of the bar in inches to be 1.5 times the tons of fiber ground per lineal foot of roller per hour.

Grouping Rollers of Different Size.

As the prevention of slip is of so much importance, the rollers should be as near the same size as possible, and the operator should try to have all the shells made of the same material. Soft, coarse-grained cast iron is the best material. Hard cast iron, semi-steel, or steel roller shells should not be used if high extraction is desired. The surface of the rollers should be strictly watched during operation and upon the first indication of any tendency to glaze up, or of any smooth patches developing, the affected part should be roughened up by

means of a pneumatic chipping hammer or some other convenient tool. This is equally important on all three rollers.

In arranging a train of mills the operator should group his rollers in lots of three according to size. The three largest rollers should be assembled in the slowest running mill, generally the first; the three smallest assembled in the fastest running mill, etc.

As in the majority of factories that have been in operation for a number of years it is practically impossible to have three rollers of the same size in each mill, the writer submits a few suggestions as to the method of arranging rollers of miscellaneous sizes.

The worst possible combination, in the writer's opinion, is a large top roller with correspondingly small feed and discharge rollers. To explain fully just why this should be so it will be necessary to theorize a little. The duty of a mill, where the cane is thoroughly prepared and properly macerated, is to pass a certain amount of this prepared cane through per hour and to extract as much juice as possible in the process. In other words, to reduce the moisture content of the bagasse leaving the mill to the lowest possible percentage. Any factor that has a tendency to increase the moisture is detrimental. Now, to take an extreme case, say we have a top roller 32½ inches diameter assembled with feed and bagasse rollers of 30½ inches diameter. The blanket will enter the mill and pass over the returner bar at the same speed as the surface of the smaller feed roller, the 30½-inch roller. The blanket should pass out of the mill at the same speed as the surface of the smaller of the two discharge rollers, the 30½ inches diameter bagasse roller. If this theory is correct, the 32½ inches diameter top roller, in the example under consideration, will have to slip 6¼ inches in each revolution. This slip takes effect on a surface of blanket of fully the width of the returner bar. It is obvious that this amount of slip going on day after day is going to wear down the top roller very quickly, but this condition is also very undesirable on account of the enormous waste of power expended in this slip. When the top roller is smaller than the feed and bagasse rollers, the blanket enters the mill and passes over the bar at the same speed as the surface of the smaller top roller, and any slip is taken up by the feed and bagasse rollers and takes effect on a comparatively small surface, eliminating to a large extent the wear of the rollers and the waste of power expended in overcoming friction of the slip. As previously stated, the blanket passes through the discharge rollers at the same speed as the surface of the smaller roller, but the writer believes this condition only holds good up to the point of contact. Immediately after passing the center or point of highest pressure, the blanket is inclined to take the fastest speed of exit, that is, the surface speed of the larger roller. Now as the bagasse in contact with the smaller roller cannot travel faster than the surface of that roller, the quicker release of the blanket in contact with the larger roller causes a series of small ruptures on that surface. If these ruptures appear, as the writer believes they do, immediately after the point of contact has been passed, it is not too much to infer that some of the juice being extracted and taking the path of least resistance to escape from the enormous pressure, will find its way into the ruptures. Where the top roller is the larger the juice in the ruptures is carried out with the blanket of bagasse until the pressure is sufficiently relieved, when

the juice is reabsorbed by the bagasse. But supposing the bagasse roller is the larger, the ruptures will take place on the bottom of the blanket, and the juice being carried out will escape through the juice grooves in the bagasse roller while still under pressure and before the bagasse has had a chance to reabsorb it. The same theory may be applied to the feed and top rollers, with this difference, however, that pressure on the blanket leaving the feed rollers is never entirely released, as the resistance of forcing the blanket over the returner bar has to be overcome.

It is the writer's opinion, founded on personal experience, that the best results (that is the lowest moisture) can be obtained in a last mill by having the bagasse roller slightly larger than the top roller. In summing up the above remarks on the different methods of arranging the rollers of miscellaneous sizes, it will be seen that it is very bad practice to assemble a large top roller with a small bagasse roller. The bagasse roller can be quite a bit larger than the top roller, however, before the detrimental effect is noticeable. The feed roller can be slightly smaller and quite a bit larger without materially affecting the extraction.

In the assembled mill, with rollers of equal or different sizes, the importance of close setting cannot be too strongly emphasized. It is worse than useless to pile weights on the accumulator, if the rollers are not set close enough to insure the weight being transferred to the blanket of bagasse. Some operators believe in setting a mill to take a certain fixed tonnage per hour, and keep running up to the full tonnage and at a uniform speed at all times. This method has much to recommend it, but unfortunately cannot always be carried out. Many factories on these Islands have to keep changing speed at any and all times to accommodate the irregularities in cane transportation. Then, again, it is not always possible to run with a blanket of the desired thickness. From unavoidable reasons irregularity in feeding will frequently occur in the very best conducted factories. To take care of these irregularities it is necessary that the mills be set as close as it is possible to get them. This is especially important in the last mill of a train; in fact the necessity of close setting increases in each mill, from first to last, and this importance is greatly magnified where the gear ratio is such that the speed of the mills increases from first to last. It is a natural error to assume that by setting the top and bagasse rollers up metal to metal, all that is possible has been done by way of close settings, losing sight of the amount of slack or lost motion that has to be overcome before the full pressure can take effect on the blanket. This lost motion is the result of a combination of small defects, sometimes unavoidable, such as play of the top brasses in the housing, badly fitting top and end caps, too small setting-up screws, slackness in king bolt and end cap bolts, badly fitting journals and spring in the mill cheeks. The inequality of the two upward forces acting upon the top roller tends to emphasize the effect of any small defect in the assembled mill. In other words, the force applied to the top roller by the bagasse roller, being greater than the force applied by the feed roller, the resultant of these two forces acts obliquely on the top roller. This, and the right-handed revolution of the top roller, both tend to lift the top roller in a slanting direction across the perpendicular, downward force applied by the hydraulics. It is the effect of this oblique force, acting on the mill cheek

instead of acting against the downward force, that is responsible for most of the lost motion.

Lining Up the Rollers.

In setting a mill the operator should always bear in mind the great importance of having the rollers parallel; carelessness in this way means a great deal of unnecessary friction through end thrust of the rollers on the journals and brasses, and may even be the cause of forcing a roller shell off the shaft.

Setting the Rollers.

The writer recommends the following method in setting a bagasse roller. With the full hydraulic pressure applied set the bagasse roller up metal to metal with the top roller, making sure that the two ends of the roller are bearing equally. Next, with the mill turning over slowly, release the hydraulic pressure, make a mark on the setting up screw on the pinion end and tighten this end up as far as it will go. By observing the position of the mark on the setting up screw on the pinion end, the other end can be tightened up exactly the same amount. It is important that the pinion end be set up first, because if the other end is tightened up first it will be found impossible to get the pinion end up the same amount. This should be gone through every day for three or four days at the beginning of the season; then afterwards, when everything is thoroughly worked into position, once every week will be enough.

No definite rule can be laid down for setting a feed roller; the operator has to set the roller just to take the desired feed, always bearing in mind that the feed opening should be as small as possible and that the roller should always be parallel with the top roller. It is a good plan to keep setting the feed roller up a little every two or three weeks, as there is a great deal of wear to be overcome; besides it will generally be found that the longer a mill has been in operation the smaller the feed opening required. Some operators maintain that closing up the feed opening too much is likely to raise the moisture content of the bagasse, but this is only possible when a mill is running very fast or with a very thin blanket, and then only when the bagasse roller is not set up properly.

Maceration.

The question of macerating may be said to work second in importance to that of application of pressure, and in a factory where the amount of macerating water applied is limited to a certain insufficient quantity it is extremely important that every drop be utilized to the best advantage. The practice usually followed in these Islands in a twelve-roller mill is to apply all the water immediately behind the third mill. The very dilute juice extracted by the fourth mill is collected in a tank and by means of a pump applied as maceration behind the second mill. The juice extracted by the third mill is also collected and pumped up behind the first mill. In some factories the juice from the second mill is applied as maceration in front of the first mill, but unless the preparatory machinery is doing exceedingly good work this last application is of very little value.

In fifteen-roller mills and nine-roller mills the same method is followed; the juice will be returned one time more in the fifteen-roller, and of course there will be one less application in the nine-roller than in the twelve-roller.

Some operators use the dilute juice from the feed rollers only for macerating in the preceding mills, and although this is a much more elaborate method, it nevertheless has much to recommend it.

Just as the engineer, who, owing to obsolete and inferior mill machinery, is handicapped and has to "carry on" at a great disadvantage, so it is in the case of inadequate boiling house equipment. Lack of capacity in heating, evaporating or boiling equipment and uneconomical handling of same, by cutting down the maceration, greatly increases the difficulty of obtaining good mill work. It is comparatively easy to apply maceration effectively where 40 to 50 per cent is carried, but where only a small amount can be carried great care has to be exercised in the application to obtain good results. The writer does not feel qualified to say what the right amount should be; it will vary with different varieties of cane and different fiber in cane. He does feel safe in saying, however, that any amount below 40 per cent is not enough.

It is very important that the maceration be distributed uniformly throughout the blanket of bagasse and that it be applied as soon as the blanket is released from the mill. In other words, it should be applied before the blanket has had time to absorb any air. For this reason it is almost essential that macerating scrapers be used, as they are designed specifically for this purpose, and although they are by no means perfect in design, nevertheless by a little judgment in manipulating them, an almost perfect maceration can be obtained. Operators should remember that it is just as important to have a perfect maceration in the first mill as in the last. The maceration water should be applied at as high a temperature as it is possible to get it—200° F. is not any too high. It is universally agreed that hot water will penetrate further into the fine particles of bagasse and absorb more sucrose than will cold water. Besides, hot water applied in front of the last mill and mixing with the extracted juice helps to keep the juice sweet and free from inversion in the process of multiple maceration. Then it is just possible that the hot water if not used as maceration would be going to waste, therefore adding it to and slightly raising the temperature of the mixed juice amounts to a slight saving of steam in the heaters.

It is absolutely essential that one man on each shift, and one man only, be instructed to look after the maceration. If every Tom, Dick and Harry be allowed to interfere with the macerating value, the results obtained may possibly be interesting, but they certainly will not be uniform. The engine tender is possibly the best man to put in charge, as he is usually fairly intelligent, has lots of time, and, knowing the speed of his engines, can with a little practice estimate fairly accurately the quantity of cane going through the mills at any and all times. He should be instructed to take samples of the crusher or first mill juice and also the mixed juice at least every hour, taught how to take the Brix of each juice and how to work out the maceration, and instructed to enter the results in a book for the day's run. He should also be instructed to use his judgment between sampling times as to the approximately correct amount of maceration to apply, if for some reason the mill has to be run slower. It should also be a

hard and fast rule that in the event of the mill being stopped the maceration be immediately shut off. Once the tender has been properly instructed it will be found that he will take pride in being accurate, and it is astonishing how uniform he will be able to keep the maceration.

In factories where the amount of maceration is limited and it is found necessary to use the very dilute sweetening off water from the mud presses as maceration in front of the last mill, it will be essential to have a boy told off to sample this sweet water also. Samples should be taken at least every half hour, and in the event of the Brix running above a specified amount, the cause should be investigated. Although it is not a correct indication of the amount of sucrose, it is a safe rule not to allow any maceration applied in front of the last mill with a Brix of over 1.5%, as it will be sure to affect the results.

Controlling the Mill Work by Mill Extraction Tests.

To insure uniform and consistently good work being done throughout the season, it is essential that the operator have the cooperation of the chemist in taking samples periodically from all the mills, thereby keeping himself posted as to what each mill is doing and enabling him to have them tuned up to the highest pitch all the time. In taking samples of individual mills, since it is comparative results that are desired, it is not really important whether those samples be "dry crushing" or otherwise. The writer, however, is not at all partial to dry crushing as a means of ascertaining the work done by individual mills. Dry crushing tests are taken under extraordinary circumstances and at the best are only an indication of pressure. In fact the results obtained should be directly proportional to the pressure applied. Dry crushing does not give any indication of the efficiency of maceration or of the correct drainage of the extracted juice. Then, again, it gives no indication as to whether the mill is properly set or otherwise, as the feeding conditions under dry crushing are entirely different than when the mill is running under normal conditions. And lastly, in taking dry crushing tests from all the mills, if it is done properly it is necessary to shut off the maceration entirely, stop the cush-cush conveyor and to allow the cane to work all the way through the train of mills. To avoid making any break in the blanket, the last mill has to be taken first. This, as can easily be seen, is a long and laborious job, besides being very hard on the mills.

The writer believes that the correct way to sample individual mills is just to take them as they run under normal conditions. In other words, find what moisture, sucrose in bagasse and extraction you are getting from twelve, nine, six and three-roller mills, respectively. The moisture is the best indication of what a mill is doing; if the moisture as indicated by the last test shows any perceptible increase over previous tests it is a sure indication that the mill requires tuning up. These tests should be taken at least twice each week, and a complete record kept for comparison from week to week and from year to year.

Large Grooving for First Mill.

In a mill where the preparatory machinery is insufficient, or in other words, where the cane entering the second mill is not sufficiently prepared to assure the

maceration being effective, it is advisable to try large grooving in the first mill. This large grooving, if the grooves in the top roller are meshed with the grooves on the bottom rollers, tends to cut up the cane, and although the extraction in the first mill may be decreased, nevertheless by the cane being better prepared to receive the maceration it really amounts to an increase in the other mills. This is the only instance where large surface grooving may be said to have preference over small surface grooving in regard to extraction.

Speed Ratios of Rollers.

It is generally agreed that the present speed ratio of mills on these Islands, where the speed increases from first to last, is out of date and undesirable in the present advanced stage of milling. It is popularly supposed that it would be more correct to have the mills all running at the same speed.

Where the question of obtaining extraction alone is considered, the correct method undoubtedly would be independent drive for each mill, and this, in the writer's opinion, is the strongest argument that can be advanced in favor of electrification of mills.

There is still some difference of opinion amongst engineers with regard to the speed at which mills should be run to do the best work. Some maintain that high surface speed of rollers with thin blanket is the correct method, while others agree with the writer, that, providing the juice drainage is sufficient, just as good results can be obtained at the same tonnage ratio with low surface speed and correspondingly thicker blanket.

In conclusion the writer, with apologies if guilty of sounding a note of discord, feels it his duty to request mill operators, especially the young, ambitious operators, not to forget that they are first of all engineers. In these days of so-called efficiency and craze for high extraction, it is only too easy to forget this very important fact.

Variety Test in Kohala.

In a small variety test comparing Yellow Caledonia, Badila and H 146, in adjoining water course, recently harvested at Union Mill Company, Kohala, the following results were obtained:

Variety	Area	Tons Cane per Acre	Q. R.	Tons Sugar per Acre
Yellow Caledonia	.185 a.	39.2	7.15	5.48
Badila	.223	35.8	6.11	5.86
H 146	.364	28.4	6.15	4.61

Land Titles and Surveys in Hawaii.*

By ARTHUR C. ALEXANDER.[1]

Introductory Note.

The following article was written for presentation to a small gathering of well-informed men and the subject is not treated in as extended or as complete a manner as would have been the case if it had been written for publication. Anyone wishing to go further into the subject is recommended to read a "Brief History of Land Titles in the Hawaiian Kingdom," by W. D. Alexander, published as an appendix to the Surveyor General's Report in 1882 and reprinted in Thrum's Annual for 1891; and also a series of articles on "Land Matters in Hawaii," by C. J. Lyons, published in the "Islander" in 1875 and reprinted in the Report of the Surveyor of the Territory of Hawaii for 1902. The various Acts of the Legislature under which the Land Commission was organized and operated may be found in the Appendix to the Revised Laws of Hawaii, 1905.

For the benefit of other surveyors a list of those who did surveying for the Land Commission is appended (Appendix A) to this article with brief comments on the quality of their work and their individual peculiarities. In preparing this list the writer has drawn freely on the experience of others as well as his own, and wishes here to express his indebtedness to those who have helped him with their comments. There is also appended (Appendix B) a discussion of the rate of change in the magnetic declination in Hawaii.

HAWAIIAN LAND SUBDIVISIONS.

Some knowledge of the ancient system of land subdivision in Hawaii is necessary in order to understand the peculiar situation that has developed from it.

The largest subdivision of land was the "moku," or district. Each of the four largest islands was divided into several such districts, the names in many cases being repeated, as the windward districts of Koolau and Hamakua and the leeward district of Kona, which appear on at least three islands. The moku seems to have been a geographical subdivision only. There were no lords or administrators over these districts, as districts.

Each moku in turn was divided for land holding purposes into a series of lands called "ahupuaas," varying greatly in size and shape. Theoretically each ahupuaa contained a "kai" (sea fishery), a stretch of "kula" (upland), and some "kuahiwi" (forest and mountain land), so that it could furnish everything that might be needed by the holding chief and his retainers for their support. As a rule, the ahupuaas consisted of strips running from the sea up the mountain side and were usually bounded by natural features, such as gulches, ridges and streams. In many instances the ahupuaa, instead of being a continuous strip, consisted of a number of detached pieces called "leles." This was particularly

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1 Manager Land and Survey Department, American Factors, Ltd.

the case where a large number of lands were crowded into a comparatively small area, as in the vicinity of the larger towns.

The ahupuaas were subdivided into smaller lands, called "ilis," the arable portions of which in turn were divided into small tracts, called "moos," or "mooainas." These last subdivisions were for purposes of cultivation only. The names of the mooainas were in reality field names. The ilis varied even more than the ahupuaas in size and form, leles being the rule rather than the exception. A distinct type among the ilis was the "ili kupono," or simply "ili ku," which was an independent subdivision for land holding within the ahupuaa. In some cases, as in the ahupuaa of Hanapepe on Kauai, where the big independent ilis of Eleele, Kuiloa, Koula, Manuahi, etc., took up practically all the land that was of value, the ili kuponos are of more importance than the ahupuaa itself.

The original subdivisions were made some time in the far distant and obscure past and have been rigidly adhered to ever since. It was the business of the inhabitants of any land to know its boundaries definitely, so that they could keep off trespassers and not trespass themselves on adjoining land. This knowledge was imparted by taking them at stated intervals on a pilgrimage around the land. The elaborate subdivision of the land is evidence of the teeming population that once existed here, which is corroborated by the testimony of early visitors and the evidences of cultivation that we find everywhere. In ancient Hawaii there was no unoccupied land. It was all "taken up."

Ancient System of Land Tenure.

Originally the ultimate title to all land was vested in the reigning chief. No one could hold or occupy land without his consent. The communal, or tribal, system of land tenure existing in other parts of Polynesia did not exist here. The lands were parcelled out among the principal retainers of the king on his accession and their tenure was not usually disturbed so long as they rendered the service and tribute exacted by their sovereign. To have disturbed them might have fomented dissatisfaction and revolt,—a condition to be avoided. The number of lands granted any chief varied with his rank and influence. Under the chiefs the arable land was parcelled out again among the common people living on the land, who in turn rendered various services to their landlord and cultivated certain pieces of land called "koeles" for him. In later years the tenants worked on the koeles once a week, on Friday, and these came to be called "poalimas," poalima being the Hawaiian word for Friday. The tenants as a rule did not migrate and lived on the same lands for generations. The fact that the landlord was dependent on them for service both in peace and war tended to render their tenure more stable. As may be seen it was strictly a feudal system, with this distinction, that the tenure of land was entirely dependent on the life of the sovereign or his ability to maintain the throne.

The name "konohiki," meaning originally the landlord's agent in charge of the land, came in time to be applied to the land under his care, "konohiki land" meaning land held by a chief, i. e. an ahupuaa or ili; and the name "kuleana," meaning originally "rights," came to be applied to the land held by the tenant.

shall use both terms in this way throughout this paper without further explanation.

Land Commission and "Mahele" of 1848.

Prior to the establishment of the Land Commission, transfers of land, in order to be valid, required the approval of the king and premier. There was no such thing as a fee simple title. With the advent of foreigners and foreign business methods, it soon became apparent that a radical change would have to be made in the system of land tenure. Fortunately the king, Kamehameha III, and the leading chiefs were thoroughly alive to the situation. In 1846 there was formed a "Board of Commissioners to Quiet Land Titles," commonly known as the Land Commission. This commission as first organized consisted of two white men, two full-blooded Hawaiians and one half-white. John Ricord, the attorney general, was chairman of the board. It organized and began its labors on February 11, 1846, and it was not dissolved until March 31, 1855, nine years later. It sat as a court of record, with power to confirm or reject all claims to land arising prior to December 10, 1845. All claimants to land were required to file their claims before the Land Commission for confirmation before February 14, 1848, or be forever barred.

I have not time to go into the details of the great "mahele," or division, of the lands that took place in 1848. The king, to his everlasting honor, voluntarily gave up all his rights in the land, which was divided ultimately into three portions,—one to the chiefs, one for the support of the government, and the third for the sovereign's personal use. These we know by the names of Konohiki, Government, and Crown Lands.[1] A one-third interest in the konohiki lands was retained by the government, and in order to get an allodial title in fee simple the payment of "commutation" to the government was required, either in land or in cash equal to one-third of the unimproved value of the land at the time of the mahele. Out of the konohiki lands were taken the holdings of the tenants, the "kuleanas." Thus the chiefs had to give up one-third of their lands to the government and a theoretical one-third to their tenants. It was only after a long and earnest discussion in the Privy Council that they consented to do this. It was a great sacrifice on their part for the common good, but at the same time they obtained fee simple titles that could not be disturbed, except by due process of law. The kuleanas, as finally decided, were exempt from commutation, except in the towns of Honolulu, Hilo and Lahaina. This was on the theory that in the country districts the government commutation having already been paid by the konohiki, the kuleanas ought to be exempt,

[1] This division is recorded in the so-called "Mahele Book." In this book the lands held by each chief are entered in two lists on opposite pages. The king signed one list quit-claiming those lands to the chief and the chief signed the other list quit-claiming the remaining lands to the king. After this subdivision was made, the king made a second subdivision of the lands given up by the chiefs, setting aside the main portion for the support of the government and retaining the rest for his own use. This second subdivision was inserted in the "Mahele Book" after the first, the two resultant lists being both signed by the king.

while the town lots, not having been taken out of konohiki land, ought to pay commutation.

The Land Commission worked with great energy and singleness of purpose and accomplished a most difficult and arduous task. They made many mistakes, but when one considers that nearly 12,000 individual claims were adjudicated by the commission, involving visits to all the principal islands and the hearing of a mass of testimony, it is surprising that more mistakes were not made. The work required haste in order to insure its completion, as there were many exigencies that might have stopped and undone all that had been accomplished, as, for instance, the death of a progressive ruler in entire sympathy with the work of the commission and the succession of one less liberal and helpful. The sins of the Land Commission were sins of omission rather than of commission, and are being gradually corrected as they come to light. Whatever injustices were committed were unavoidable under the circumstances.

Boundary Commissioners.

It was manifestly impossible, with the limited time available and the scarcity of surveyors, to survey all the konohiki lands, and in 1852 the Land Commission was empowered by Act of the Legislature to grant awards on konohiki lands by name only and without survey. Some ten years later, by another Act of the Legislature, Boundary Commissioners were created, to whom the owner of any konohiki land might apply for the settlement of its boundaries.[2] It is nearly fifty-eight years since the first Boundary Commissioners were appointed, and yet there are a surprisingly large number of lands whose boundaries have never been surveyed or settled. In the district of Lahaina, for instance, there are over twenty such lands. The difficulties in the way of determining the boundaries of these lands have been increased immeasurably by the death of all the old "kamaainas" who were familiar with these boundaries. In order to close up the work of the Boundary Commissioners the last Legislature passed an act requiring the surveying and settling of all such boundaries within four years from July 1, 1919, and it is to be hoped that this will be accomplished.

Awards, Patents and Deeds.

Many of the owners of konohiki lands assigned to them in the mahele failed to apply for Land Commission Awards within the allotted time. For the relief of these, an act was passed in 1860 empowering the Minister of the Interior

[2] At first there was a Boundary Commission, consisting of two members, appointed for each judicial circuit; then the plan of a single Commissioner for the whole group was tried, and finally, in 1868, the present arrangement of a single Boundary Commissioner for each judicial circuit was adopted.

to grant awards on these lands if applied for before the last day of June, 1862. Sixty-four awards, known as "Mahele Awards," were issued under this act.[3]

By Act of the Legislature in June, 1848, certain government lands in the district of Honolulu were set aside for the support of the garrison at the Fort, known as "Fort Lands." In 1851 these lands were sold at auction, after fifty acres had been reserved for the Royal Hawaiian Agricultural Society. A series of separate awards for these lands was issued by the Land Commission, designated by the letters "F. L." (Fort Lands). This makes three classes of awards, —(1) the Land Commission Award pure and simple, (2) the Land Commission Award F. L., and (3) the Mahele Award.

These awards conveyed a title to the land "less than allodial," under which, by Act of the Legislature in 1854, the owner might bring any action at law as if he "had received a Royal Patent for the same." The holder of an award was entitled to a Royal Patent in confirmation of his title on application to the Minister of the Interior and the payment of the commutation, but, as they could not be dispossessed of the land, quite a large number of owners were content to let things run on as they were without applying for patents. It was only a few years ago that a law was passed providing for the appraisement of the commutation on all lands subject to commutation that had not been patented and the adding of interest to the commutation if not paid before a certain date. This has resulted in patents being issued on most of the unpatented awards.

In addition to the patents issued in confirmation of awards, there are three other classes of patents,—(1) patents issued on government land sales and homestead lots, known as "Grants"; (2) a few patents issued on government lots and remnants in Honolulu, known as "Public Works Grants" and designated by the letters "P. W.," and (3) patents issued in 1883 to the Board of Education on various school and church lots throughout the islands. The government in recent years has also conveyed title by quit-claim and exchange deeds, and the writer knows of at least one so-called "adjustment deed," but in this case the land was also covered by a patent. There are many cases where more than one award or where an award and grant were inadvertently issued on the same land. Examples are also common, particularly in recent times, where one title has been knowingly superimposed upon another. This has happened where the government has acquired land already under patent or award and has reconveyed it in parts, issuing patents for these parts. All this has tended to increase the complexity of our land titles, already complex enough.

The crown lands, until 1865, when an act was passed making them inalienable, were treated by the sovereign as his own private property and freely sold to fill the royal purse, which suffered from chronic depletion. These conveyances of crown lands are known as "Kamehameha III and IV Deeds." They add another element of complexity to our system of original land titles,—a system that has simply grown without plan or forethought.

[3] A second act for the relief of delinquent konohikis was passed by the Legislature in 1892, whereby the Minister of Interior, under certain conditions, was "authorized to issue Royal Patents (Grants) to all konohikis, or to their heirs or assigns, where such konohikis failed to receive awards for their lands from the Land Commission or from the Minister of Interior as provided by the Act of August 24th, 1860." This Act remained in force until June 1, 1895, on which date all unawarded and unassigned lands became finally the property of the government.

Complications of Title.

The Land Court, established in 1903, was expected to simplify matters by uniting in one title adjoining groups of heterogeneous titles. In time it will do so, but up to the present it has tended to complicate rather than simplify.

To show the heterogeneous character of Hawaiian land titles let us take a hypothetical case. Suppose a tract of land comprising originally four separate pieces, consisting of (A) land awarded and patented, (B) land awarded and not patented, (C) land awarded by name and not patented, (D) land registered in the Land Court, is subdivided into lots for sale. The lots are put on the market at prices depending solely on the character of the land and their relative positions and not in any way on the title. The purchasers of lots containing only portions of (A) obtain titles that are complete. The purchaser of a lot containing part of (B), although he pays the same relative price, to perfect his title must have a description prepared of the unpatented portion of his lot, pay commutation on it and pay for a patent. If the lot contains part of (C), after having had a survey made of this part, the purchaser will also have to go before the Boundary Commissioner and get a Boundary Certificate before he can pay the commutation and get a patent. If there is a part of (D) in the lot bought, he must have a plan and description prepared of this part for the Land Court so as to get a Land Court Certificate of Title for it. If he is unfortunate enough to buy portions of two or three of these pieces, he may have to pay for his lot twice over before he can get a clear title. This is an extreme case, but it illustrates well the want of simplicity in our land titles.

Character of Early Surveys.

The greatest defect of our land system, however, has not been its complex character, but has been the imperfect character of the earlier surveys and descriptions. Under the conditions existing at the time of the Land Commission the wonder is that so much good work was done. With ten or twenty thousand surveys to be made at the same time, with no trained surveyors to be had, and with a limited supply of rather inferior instruments, the Land Commission was certainly "up against it." At the same time the members of the Commission were absorbed in the legal phases of their work and did not seem to realize the importance of accurately describing the lands awarded. A remarkably able statement of rules and principles was drawn up for the guidance of the Commission, but the surveyors that they employed had no such statement to guide them. They were not informed as to how they were to do their work, what land was to be included or what excluded, what degree of accuracy was required, or how corners were to be marked. With a few shining exceptions, most of the surveyors had no idea of the value of accuracy, and the instruments used were of all kinds from a ship's compass to an engineer's theodolite. No one was required to show his qualifications before being employed by the Commission as a surveyor, and absolutely no effort was made to test the accuracy of the work done. As a matter of fact, under the circumstances it would have been a physical impossibility to have done so. Only in rare instances were corners marked and

adjoining surveys made to agree. In general each piece of land was surveyed independently, no stakes being placed. Consequently overlaps and laches were the rule rather than the exception. Add to this the erratic behavior of the magnetic needle here and the meager descriptions given, and you have some idea of the difficulties met in relocating the original boundaries of the awards and why a special sort of education is required in order to do land surveying in Hawaii.

In addition to technical training and experience, a good understanding of the Hawaiian language is necessary to the local surveyor, and also some knowledge of the individual peculiarities of the early surveyors and their work. One of these, for instance, used a very defective compass and, while his distances are good, his bearings are utterly unreliable; another had a compass with the line of sight at an angle of a few degrees with its needle, so that his surveys have all to be swung through the same angle to fit the ground; another used a theodolite and measured the angle made by each line with the magnetic bearing of the first course; others, instead of writing out their descriptions in terms of the magnetic bearings at each corner, used the average magnetic north of all the corners, obtained by taking back sights at each corner.[4] These are only samples of the things surveyors here have to learn by experience. The magnetic needle here will often show a variation in direction of over a degree in a distance of a few hundred feet, and different compasses will sometimes show almost as great a variation between their readings.[5] This increases still more the difficulty of retracing the original surveys.

Changes in Magnetic Declination.

Another important item that has to be allowed for in rerunning old magnetic surveys is the progressive change in the direction of the magnetic north. From the time of the Land Commission to date (March, 1920) there has been a total change of approximately 2° 00′. This change has been in a clockwise direction. As a resunlt, 2° 00′ must be added to all northwest and southeast bearings of 1850, or thereabouts, in order to translate them into magnetic bearings of 1920, and similarly the same amount must be subtracted from all northeast and southwest bearings of 1850. The rate of change is subject to a progressive variation, which, though small, is not negligible. This change in the magnetic meridian at the present time is at the rate of nearly 2.25 minutes per annum.[6]

Relocation of Boundaries.

To go on the ground without any previous preparation and attempt to locate the corners of an award would be folly in most cases. The problem is not nearly so simple. First, the original description should be tested for closure. This will help in adjusting the sides if it does not fit the ground. A preliminary survey should then be made of the ground and all landmarks carefully located and

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[4] See "Appendix A" to this article for list of early surveyors with comments.

[5] The local variations in the magnetic declination are discussed quite fully in "No. 11" of C. J. Lyons' articles in the "Islander," to which anyone interested in the subject is referred.

[6] See "Appendix B" to this article for a more detailed statement as to the rate of change in the magnetic declination.

plotted on paper, the magnetic declination being observed. It requires some experience and judgment to determine what landmarks are pertinent. Now with everything on paper in miniature, the surveyor can plot on his plan the original survey and shift and adjust it until he is satisfied that he has the best location. That is not all, however; he should also take into account the adjoining surveys and plot them too on the plan, remembering the rule that the earlier title governs, for, as I have said, adjoining descriptions were not usually made to fit. Having satisfied himself as to where the boundaries lie, it is not a difficult matter to run them out and mark them on the ground. This may seem like a long drawn out process, but it is the only safe and sure way to proceed and is invariably the quickest way to get satisfactory results. It is needless to say that the problem of overlaps and laches is one of the most difficult that the surveyor in Hawaii has to solve. Another difficult problem, which, however, is not peculiar to Hawaii, is that of shifting natural boundaries, as streams and shoreline.

Work of Hawaiian Government Survey.

The awards issued by the Land Commission are recorded in ten huge volumes. There is a statement as to general location, a brief description by metes and bounds of each parcel, usually in Hawaiian, an outline plan showing the adjoining owners and nothing more, sometimes not even as much. Practically no general maps showing the relative positions of these parcels with respect to each other and the surrounding topography were in existence before the establishment of the Hawaiian Government Survey in 1872. The work that was done by this survey in the following years in the way of preparing such maps has been of inestimable value to the public. It is hard enough to locate a kuleana,—say in Waikiki,—with a general map of the district, but think what it would be without such a map! Another great service that the Government Survey has rendered, which the general public cannot appreciate, has been the introduction of a system of surveying by the true meridian instead of the magnetic and the establishment of carefully located and marked points from which the direction of the true meridian can be readily obtained. Still another service rendered by the Government Survey has been the raising of the standards of local surveyors and the improvement in their methods over what they were prior to 1872. It is fortunate for us that this valuable department has been kept almost entirely free from political interference during the many changes in government that have taken place since it was started and has been able to maintain throughout this period the same high standard of work and service.

Improvement in Standards of Surveying.

A feature of land surveying in Hawaii that deserves mention and which people are not generally aware of, is the great improvement during the last twenty years in the quality of the work done by the local surveyors. Twenty years ago a survey closing within one foot in one thousand was considered quite accurate, even in town. What we might call "precise surveying" was not

at all common. Now the situation is reversed and "precise surveying" is the rule instead of the exception.

Several factors have contributed to this result, the most potent of these being the influence of the Land Court. When the title of a piece of land is guaranteed for all time by the government, it is absolutely necessary that it be described in such a manner and with such accuracy that there can never be any question as to the location of its boundaries. Those who were responsible for the drafting of the Land Registration Court Act passed in 1903 and for its early administration appreciated this fact fully and saw that the characer of the surveys filed was properly safeguarded. During the first few years of its existence the Land Court employed technical experts to check the accuracy of these surveys. Recent amendments to the act have placed this work under the Territorial Surveyor and require the testing of all surveys on the ground. Having been connected with the Land Court in an official capacity for several years, the writer has observed with considerable satisfaction the salutory effect its standards have had on the local surveyors.

Another factor in making the local surveyors improve the quality of their work is the act relating to the filing of plans passed in 1905, and amended a few years later so as to require all plans filed with the Registrar of Conveyances to be tested and approved by the Territorial Surveyor before acceptance. It seems almost incredible, but up to the passage of this act land in this city was bought and sold by lot and block number as shown on maps copied in the books of the Registry of Conveyances,—maps which do not give the length and bearing of a single line and which are of such a scale and so imperfectly drawn that it is impossible to even approximate the true dimensions of the lots. Such a law was absolutely necessary for the protection of the public and should have been in force years ago.

A third and more recent step in advance has been the application, where the government is involved, of the same safeguards to the surveys filed with the Commissioners of Boundaries. Maps are also required to be filed with the Commissioners to be kept as permanent records similar to the maps accompanying Land Court Petitions. Anyone who has dug over the records of the Boundary Commissioners, which only contain notes of survey unilluminated by maps, will appreciate this change. The evolution in the methods of these Commissioners is worthy of note from the days when not even notes of survey were required and the boundaries of lands were adjudicated and settled by reference to natural features, to the present time when not only are maps and notes of survey required, but these are also carefully scrutinized for possible errors.

As has been shown, there has been real progress made during the last twenty years towards standardizing our land surveys, if not our land titles, and it is to be hoped that there will be no retrogression in the future.

APPENDIX A.

Surveyors for the Land Commission.

Alexander, W. P.—One of the most careful surveyors of that time.

Bailey, Edward—Work was fairly good; main fault was the correcting of errors of closure in the office without testing on the ground.

Baldwin, Dwight—Surveyed only one or two small pieces in Lahaina.

Bishop, Artemas—Had no conception of the value of accuracy or the desirability of making adjoining surveys agree, consequently his surveys are extremely inaccurate and inconsistent.

Dillon, James—Work was fairly good; used an engineer's theodolite and the magnetic north of the initial point, a method which has the fault that a blunder in reading or recording the magnetic bearing of the first course may swing the whole survey through an angle of several degrees.

Dole, Daniel—Surveyed only a few small kuleanas in Waikiki.

Emerson, John S.—The accuracy of his work was impaired by the employment of an unreliable chainman, who, in staking out land sales, Joseph S. Emerson reports, was in the habit of placing the pin in the ground beyond the end of the chain, thus giving more land than the calculated area called for.

Fuller, John—An extremely careful surveyor; both Joseph S. Emerson and E. D. Baldwin, who have had much experience in rerunning his surveys, say that he was the most accurate surveyor of his time.

Gower, John T.—A very careless surveyor.

Hopu, Asa—This surveyor evidently used a compass that was quite "off center," as his surveys have to be swung about 4° counterclockwise to fit the ground.

Kahema, Job—Work was poor.

Kalama, S. P.—One of the most reliable native surveyors of that time, with a very extensive knowledge of the names and boundaries of Hawaiian lands.

Kalanikahua, D.—As far as I can learn, not a very reliable surveyor.

Kaona, J.—Surveyed only a few small kuleanas near Honolulu.

Keohokalole, Abraham—Surveyed only a few small kuleanas in Wailuku, Maui; work was revised by Edward Bailey.

Kittredge, Chas. S.—A well trained surveyor; work was not as good as one would expect from his training.

Lyman, Fred. S.—A very careful surveyor.

Lyman, Henry M.—Like his brother, a very careful surveyor; said by C. J. Lyons to have used the average magnetic north in writing out his descriptions.

Lyons, Curtis J.—Perhaps the most careful and conscientious surveyor of that time; used the "average needle" in his descriptions.

Makalena, John W.—Work fairly good, except when he attempted to survey large tracts.

Meyer, R. W.—Said to have been educated in Germany as a civil engineer; a very careful and intelligent surveyor.

Metcalf, Theophilus—One of the good surveyors of that time; described by C. J. Lyons as "a very shrewd and practical man, whose surveys have the merit of always exhibiting and referring to natural features for fixing the lines run." His compass is said by the same authority to have read about 50′ to the east of magnetic north, so that his surveys should be corrected this amount before being run out.

Nahale—Did some surveying in Wailuku, Maui; work revised by Edward Bailey.

Pease, W. H.—One of the most careless and unreliable surveyors of that time.

Pelham, John—Another very unreliable surveyor.

Polapola, John—Only made a few surveys of small pieces; work said to have been fair.

Richardson, George—Work said to have had the same fault as his brother John's (see below); they may have used the same compass.

Richardson, John—Must have used a very defective compass; his distances are good, while his bearings in most cases are quite unreliable.

Rowell, G. B.—Only did a limited amount of surveying at Waimea, Kauai.

Thurston, Asa G.—Work was fair.

Turner, A. F.—Said to have used an English theodolite, and, like James Dillon and Wm. Webster, to have written his notes out in terms of the magnetic north of the initial point. His surveys as a rule fit together and close well, but are not easy to rerun, many of them bearing strong evidence of having been "doctored."

Ua, L. S.—Work was good for a native surveyor; like Kalama and Makalena, Ua had an intimate knowledge of Hawaiian lands and boundaries.

Webster, William—Perhaps the best trained and qualified civil engineer in the islands at that time; a very careful surveyor, using a theodolite and the initial magnetic north.

Most, if not all, of the early native surveyors were trained at Lahainaluna School under W. P. Alexander. While not always reliable, they were never guilty in their kuleana surveys of such grossly inaccurate work as was done by some of the white men. They also had a great advantage over many of the white surveyors in their intimate acquaintance with Hawaiian land matters and the language.

APPENDIX B.

Rate of Change in the Magnetic Declination in Hawaii.

The greatest difficulty in determining the rate of change in the magnetic declination in Hawaii has been, until recent years, the lack of magnetic observations free from instrumental errors. There is available a mass of readings of the magnetic needle at a great many different points on the islands covering intervals of from fifty to seventy years, but these have been made with different instruments and under such diverse conditions that they are almost valueless for purposes of comparison.

Mr. C. J. Lyons reports that in 1853 he "took, with great care, the bearings of a number of well defined mountain summits from a known locality on Hawaii (at Waimea), where no change in the needle would be caused by moving 40 or 50 feet in any direction. In 1872 the same bearings were observed with the same instrument, which at both times was in good order. The difference was 40′, plus on northwesterly bearings and minus on northeasterly." This gives an average annual rate of a little less than 2′, which was adopted and used for many years by the Hawaiian Government Survey. That this rate is too large has been the almost universal experience of local surveyors during the last twenty years.

In March and April, 1873, Prof. W. D Alexander, Superintendent of the Hawaiian Government Survey, occupied a series of triangulation stations about Pearl Harbor. At most of these stations readings were taken of the magnetic needle. These give the magnetic declination, as determined by the instrument used, at a number of points in a region of coral formation remarkably free of lava rock and from magnetic disturbances of any kind. To get the change of magnetic declination since 1873, the writer, with the same instrument, in April of this year (1920), made careful measurements of the magnetic declination at, or near, six of the stations occupied by Prof. Alexander. The results, which were fairly concordant, gave a weighted mean of 1° 13′ for the total increase in the magnetic declination since 1873, or an average of 1.55′ per annum. This result combined with Mr. Lyons' gives a total increase from 1850 to 1920 of very nearly 2° 00′, as follows:

1850 to 1853, at 2′ per annum	0° 06′
1853 to 1872 (C. J. Lyons)	0 40
1872 to 1873, at 2′ per annum	0 02
1873 to 1920 (Alexander)	1 13
Total	2° 01′

The first magnetic measurements free of instrumental errors were made at various points in the islands by E. D. Preston of the U. S. Coast and Geodetic Survey in 1892.

Similar measurements at some of the same points were made by L. A. Bauer and E. R. Frisby in 1900 and S. A. Deel in 1906. Since 1902 a magnetic observatory has been maintained by the U. S. Coast and Geodetic Survey at Sisal, Ewa, on the extensive coral flat lying between Ewa Plantation and Barber's Point.

From the magnetic measurements made by Mr. Preston in 1892 and Mr. Deel in 1906 the writer has compiled the following table:

Station	Interval	Increase in Declination	Annual Rate
Cocoanut Island, Hilo.....	1892.6 — 1906.3	27.0′	1.9′
Napoopoo, Hawaii	1892.6 — 1906.3	38.8	2.9
Waimea, Hawaii	1892.5 — 1906.3	21.8	1.6
Lahaina, Maui	1892.6 — 1906.4	19.8	1.4
Kahuku, Oahu	1891.9 — 1906.2	21.6	1.5
Waimea, Kauai	1892.7 — 1906.4	7.4	0.55
Honolulu, Oahu	1892.4 — 1906.2	18.8	1.4

The abnormally large increase in declination in the rocky region of Napoopoo, Hawaii, and the abnormally small increase at Waimea, Kauai, on a rocky bluff, indicate that the environment is not without influence upon the rate of change. Mr. Preston in his report expresses the fear "that local attraction might influence the work" at the Waimea (Kauai) Station. The results from the measurements taken at these places in 1900 are not very concordant and have been omitted.

From the reports of the magnetic observatory at Sisal, Ewa, the following mean annual magnetic declinations and annual changes in declination have been compiled:

Year	Declination	Annual Change	Year	Declination	Annual Change
1902	9° 19.1′ E.		1911	9° 32.2′ E.	0° 02.5′
1903	19.8	0° 00.7′	1912	34.8	2.6
1904	20.9	1.1	1913	37.3	2.5
1905	21.7	0.8	1914	39.6	2.3
1906	23.0	1.3	1915	41.6	2.0
1907	24.3	1.3	1916	43.9	2.3
1908	25.7	1.4	1917	46.3	2.4
1909	27.3	1.6	1918	48.6	2.3
1910	29.7	2.4	1919	50.8	2.2

These results show a steady increase in the annual change in declination up to 1912 and a decrease since then.

The work of the U. S. Coast and Geodetic Survey since 1892 has furnished a scientific basis for correcting magnetic surveys, which will become more and more valuable to local surveyors as time goes on and the results of the magnetic observations at Sisal accumulate.

Seedlings Under Drought Conditions.

At Hamakua Mill Company eight of the so-called "400 Seedlings" and four of 1914 propagations grown under *drought conditions* were cut on July 24-28, 1920, for use as seed in a regular variety test with Yellow Caledonia. H-470 easily led the group of seedlings. The following table gives estimated yields and analysis of the juice:

									Estimated Yields*
	Par-						Seed	P. A.	P. A.
Var.	ent	Brix	Pol.	Pur.	Q. R.	Lines	Bags	T. C.	T. S.
H 470	H 240	20.2	18.84	93.1	6.89	5	45	27.00	3.92
H 469	H 240	20.2	18.07	89.6	7.25	7	56	24.00	3.31
H 472	H 240	19.1	17.66	92.7	7.29	6	48	24.00	3.29
H 471	Str. Mex.	19.0	17.74	93.2	7.28	7	54	23.14	3.18
H 467	H 146	20.8	18.74	89.9	7.00	9	62	20.66	2.95
H 468	Str. Mex.	...	....	...	...	4	28	21.00	...
H 4142	Lah.	21.0	19.51	92.9	6.60	3	19	19.00	2.88
H 4105	Lah.	20.0	18.36	91.8	7.03	7	46	19.71	2.80
H 4174	Lah.	18.6	16.80	90.3	7.77	6	43	21.50	2.77
H 4132	Lah.	19.8	18.70	94.4	6.85	3	16	16.00	2.34

* Lines were 120 feet long. In figuring ton cane per acre, it was assumed that 1 bag of seed per line would give 3 tons cane per acre.

The seed cane was shipped from Honolulu, May 24, 1918, so the seedlings were about 26 months old.

Grown under adverse conditions, when the yields of Yellow Caledonia were cut in half the above figures show the behavior of some of the new varieties under unfavorable circumstances.

[W. P. A.]

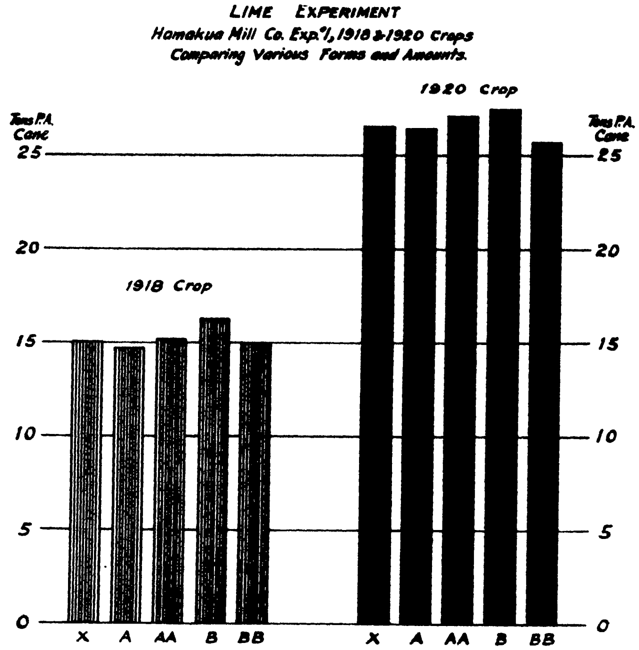
Liming at Hamakua Mill Co.

Hamakua Mill Co. Experiments No. 1 and No. 2, 1918 and 1920 Crops.

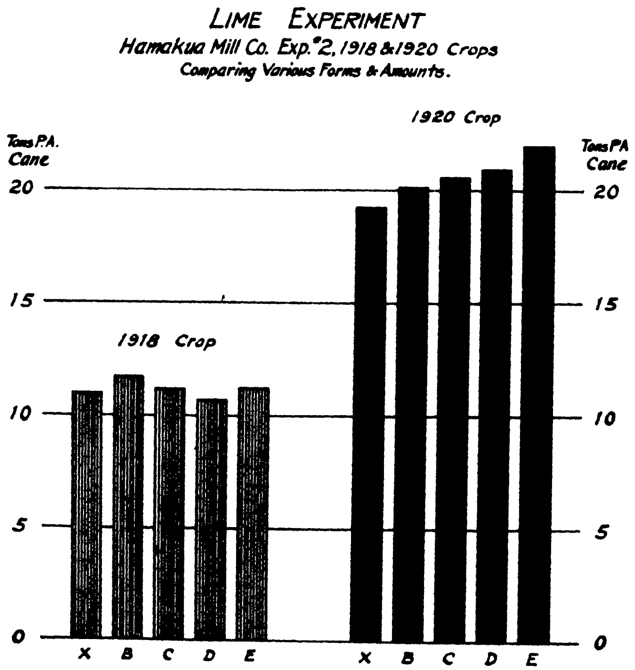
In these two tests the comparative value of varying kinds and amounts of lime was studied. The cane involved was D 1135, second ratoons, long. The experiments are located in Field 19, at an elevation of 2100 feet. Both of the crops harvested suffered from drought, especially the 1918 crop. All the plots in these tests received uniform fertilization by the plantation.

The lime was applied in October, 1916, for the 1918 crop. Since then no further applications of lime were made.

The lime treatments to the various plots, and tabulated results are as follows:



X = No sand or lime.
A = 2 tons sand.
B = 2 tons ground lime rock.
AA = 4 tons sand.
BB = 4 tons ground lime rock.



X = No lime.
B = 2 tons ground lime rock.
C = 1 ton quick lime.
D = 3½ tons quick lime.
E = 7 tons ground lime rock.

EXPERIMENT NO. 1.

Plots	Treatment*	Yields per Acre					
		1918 Crop			1920 Crop		
		Cane	Q. R.	Sugar	Cane	Q. R.	Sugar
A	2 tons sand	14.7	7.82	1.88	26.4	7.65	3.44
Adj. X ...	No sand	15.4	7.74	1.99	25.4	7.54	3.37
B	2 T. ground lime rock	16.3	8.03	2.03	27.5	7.41	3.71
Adj. X ...	No ground lime rock	15.6	7.76	2.01	28.4	7.53	3.77
AA	4 tons sand	15.2	8.00	1.90	27.1	7.50	3.60
Adj. X ...	No sand	14.5	7.75	1.87	26.6	7.54	3.53
BB	4 T. ground lime rock	15.0	7.90	1.90	25.7	7.60	3.39
Adj. X ...	No ground lime rock	15.1	7.71	1.96	24.4	7.44	3.28
Avg. of all no lime and sand plots		15.1	7.71	1.96	26.5	7.53	3.52
Avg. of all lime and sand plots ..		15.3	7.93	1.93	26.7	7.54	3.53

* Sand and lime applied October, 1916. None applied for the 1920 crop.

EXPERIMENT NO. 2.

Plots	Treatment*	Yields per Acre					
		1918 Crop			1920 Crop		
		Cane	Q. R.	Sugar	Cane	Q. R.	Sugar
B	2 T. ground lime rock	11.7	8.12	1.44	20.1	8.45	2.39
Adj. X ...	No ground lime rock	11.3	8.25	1.37	20.7	7.89	2.62
C	1 T. quick lime	11.2	8.48	1.32	20.5	7.46	2.75
Adj. X ...	No quick lime	10.8	8.18	1.32	18.6	7.89	2.35
D	3½ T. quick lime	10.7	8.49	1.26	20.9	7.82	2.68
Adj. X ...	No quick lime	11.3	8.25	1.37	20.7	7.89	2.62
E	7 T. ground lime rock	11.2	8.30	1.35	21.9	8.13	2.69
Adj. X ...	No lime rock	10.9	8.02	1.36	17.9	7.89	2.27
Average of all no lime plots.....		11.0	8.21	1.34	19.2	7.89	2.43
Average of all lime plots........		11.2	8.36	1.34	20.8	7.91	2.63

* Lime applied October, 1916. None applied for the 1920 crop.

In four years, or during the period of two crops, lime in various forms has not increased the yield of cane in these two experiments sufficiently to make such applications profitable.

In Experiment No. 1, where the comparisons are between treatments of coral sand, a ground lime rock (a preparation which in 1916 was receiving considerable attention) and no lime, the two harvests of 1918 and 1920 give consistent negative results — that is, no increased yields were obtained from the lime plots.

In the 1918 harvest of Experiment No. 2, the different lime treatments produced no increased yield over no lime.

In Experiment No. 2, for the 1920 harvest, when the lime plots are compared with the adjoining check plots, the yields of cane are not consistent. The "C" and "E" plots show slight gains in favor of lime, while the "B" and "D" plots show losses. The average of all the lime plots show a gain of 1.6 tons of cane, or .2 ton sugar.

In Experiment No. 2, an effort was made to add sufficient lime and ground lime rock to neutralize the acidity of the soil. However, soil samples taken in October, 1919, showed that the soils had not been neutralized. The acidity in the "D" plots receiving the heaviest application had been reduced about one-half, while those receiving the less amount showed no decrease in the acidity of the soil.

Details of Experiment No. 1.

Object:

1. To test the effect of lime on acid soils.
2. To compare the value of coral sand and ground Waianae limestone.

Location:

Hamakua Mill Co., Field 19, Section 49.
Elevation of field—about 2100 feet.

Crop:

D 1135 ratoons, long.

Layout:

Number of plots, 32.
Area of plots, each 1/10 acre; consisting of 5 rows, 4.48'x194.4'; lines 3 and 4 to be harvested and lines 1, 2 and 5 to be used as guard rows.

Plan:

APPLICATION OF LIME ON OCTOBER 10 AND 16, 1916.

Plots	No. of Plots	Coral Sand	Ground Waianae Limestone
A	4	2 tons per acre, or 400 lbs. per plot	....
AA	4	4 tons per acre, or 800 lbs. per plot	....
B	4	....	2 tons per acre, or 400 lbs. per plot
BB	4	....	4 tons per acre, or 800 lbs. per plot
X	12	None	None

NOTE:—The fertilization of the experiment carried on by the plantation uniform with the adjoining field.

Experiment planned by L. D. Larsen and W. P. Alexander.
Experiment laid out by W. P. Alexander.
Experiment harvested by W. L. S. Williams.

Details of Experiment No. 2.

LIME EXPERIMENT
Hamakua Mill Co. Exp. #1, 1920 Crop
Field 19. Elevation 2100 ft.

Tons Cane per acre

1 A 29.47	
2 X 28.73	
3 B 29.17	
4 X 31.74	
5 AA 32.15	
6 X 22.61	
7 BB 23.88	
8 X 26.83	
9 A 27.08	
10 X 26.39	
11 B 30.92	
12 X 26.86	21 AA 24.46
13 AA 27.03	22 X 23.54
14 X 21.52	23 BB 22.67
15 BB 25.56	24 X 22.58
16 X 23.79	25 A 21.78
17 A 28.95	26 X 20.13
18 X 29.41	27 B 22.43
19 B Discarded	28 X 24.70
20 X 39.95	29 AA 22.11
	30 X 22.82
	31 BB 30.78
	32 X 33.86

Summary of Results

Plots	No. of Plot	Treament	Yields Per Acre: Cane	Q. R.	Sugar
X	16	No Lime	26.5	7.53	3.52
A	4	2 tons of Coral Sand	26.4	7.65	3.44
AA	4	4 tons of Coral Sand	27.1	7.50	3.60
B	4	2 tons of Ground Waianae lime stone	27.5	7.41	3.71
BB	4	4 tons of Ground Waianae lime stone	25.7	7.60	3.39
		Average of all lime plots	26.7	7.56	3.53
		Average of all no lime plots	26.5	7.53	3.52

LIME EXPERIMENT
Hamakua Mill Co. Exp. #2, 1920 Crop
Field 19. Elevation 2100 ft

Tons Cane per acre

1 X 18.46	
2 C 21.43	
3 B 20.40	
4 X 22.30	
5 D 20.79	
6 E 21.64	
7 X 18.76	
8 C 20.93	
9 B 24.41	
10 X 21.50	
11 D 21.64	
12 E 21.71	15 B 19.65
13 X 18.12	16 X 22.81
14 C 19.86	17 D 20.56
	18 E 25.37
	19 X 18.96
	20 C 19.93
	21 B 16.13
	22 X 16.11
	23 D 20.69
	24 E 18.81
	25 X 15.76

Summary of Results

Plots	No. of Plot	Treatment	Yields Per Acre: Cane	Q. R.	Sugar
X	9	No lime	19.2	7.89	2.43
C	4	1 ton lime	20.5	7.46	2.75
B	4	2 tons ground lime rock	20.1	8.45	2.39
D	4	3.5 tons of lime	20.9	7.82	2.68
E	4	7 tons of ground lime rock	21.9	8.13	2.69
		Average of all lime plots	20.8	7.91	2.63
		Average of all no lime plots	19.2	7.89	2.43

Object:

1. To compare the value of lime and ground lime rock.
2. To determine the value of different amounts of lime.

Location:

Hamakua Mill Co., Field 19, Section 49.
Elevation of field—about 2100 feet.

Crop:

D 1135, second ratoon, long.

Layout:

Number of plots, 25.
Area of plots, each 1/10 acre; consisting of 5 rows, 4.53' wide and 192.3' long. Lines 3 and 4 are to be harvested. Lines 1, 2, 5 are guard rows.

Plan:

APPLICATION OF LIME ON OCTOBER 16–18, 1916.

Plots	No. of Plots	
X	9	No form of lime
C	4	1 ton of lime per acre, or 200 lbs. per plot
B	4	2 tons ground lime rock per acre, or 400 lbs. per plot
D	4	3½ tons lime per acre, or 700 lbs. per plot
E	4	7 tons ground lime rock per acre, or 1400 lbs. per plot

Fertilization of the experiment will be uniform with the adjoining field, and carried on by the plantation.

Experiment planned by L. D. Larsen and W. P. Alexander.

Experiment laid out by W. P. Alexander.

J. A. V. — W. P. A.

Liming Gives Negative Results.

Grove Farm Experiment No. 8—1920 Crop.

This was a test comparing the relative value of varying amounts of sand with no sand on an acid, virgin soil. The cane was Yellow Caledonia, plant, on a non-irrigated field. All plots received a uniform application of fertilizer by the plantation together with the surrounding field; this included 500 pounds per acre of reverted phosphate.

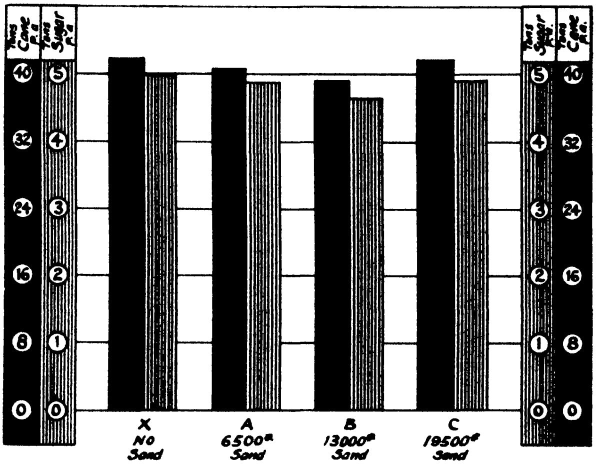
The sand was applied broadcast, and harrowed in, after which the field was furrowed and planted. The following amounts of sand were applied:

X plots = no sand
A " = 3¼ tons of sand
B " = 6½ " " "
C " = 9¾ " " "

The results of the harvest are given as follows:

No. of Plots	Treatment	Yield per Acre		
		Cane	Q. R.	Sugar
9	No sand	41.9	8.41	4.98
9	3¼ tons of sand per acre	40.7	8.29	4.91
10	6½ tons of sand per acre	39.5	8.45	4.68
10	9¾ tons of sand per acre	42.0	8.52	4.93
Average of all no lime plots...........		41.9	8.41	4.98
Average of all lime plots..............		40.7	8.41	4.84

CORAL SAND ON ACID VIRGIN SOIL
Grove Farm Plantation Experiment #8, 1920 Crop



Again we obtain results contrary to popular belief and teachings. That is, these results, as have been the case with a large majority of our lime experiments, show no profitable response to liming. This applies particularly to liming acid soils. In acid soils we have never obtained experimentally any marked increase in yields from liming. On the Island of Oahu, at Oahu Sugar Co. * and at Waipo Substation * we have obtained increased yields from Lahaina and H 109 when liming neutral soils. On the same soil we obtained no response when liming D 1135.

We realize that these tests do not cover the full range of Hawaiian conditions. A number of plantation managers report benefits from liming. This statement of the results of these tests must not be accepted as a general recommendation against liming, but rather as indicating the value of testing the question very thoroughly.

Details of Experiment.

SAND VS. NO SAND

Object:

1. To determine the value of sand on acid soil.
2. Amount to apply.

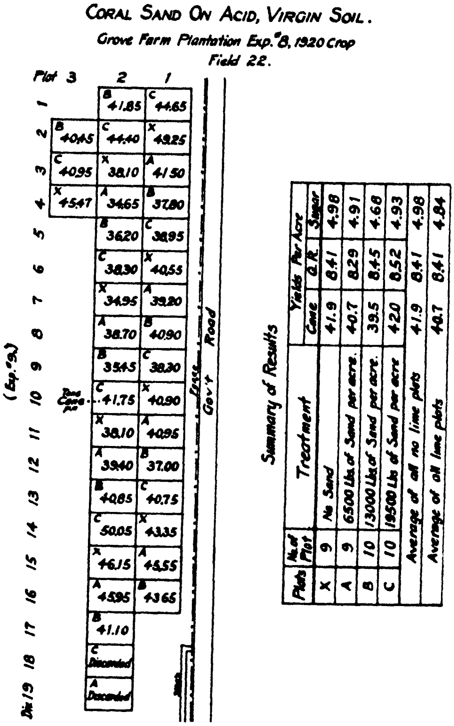
* See Planters' Record, Vol. XVIII, p. 578.

* See Planters' Record, Vol. XV, p. 367.

Location:

Field 22.

Crop:
Yellow Caledonia plant cane on virgin soil, unirrigated.



Layout:

Number of plots = 38.

Size of plots = 1/10 acre (60'x72.5').

Plots composed of 13 straight lines, 4.7'x72.5'.

Plots are separated by 3' roadways running at right angles to the rows.

Plan:

Plots	No. of Plots	Plot Numbers	Lbs. Sand per Acre
X	9	2.1, 3.2, 4.3, 6.1, 7.2, 10.1, 11.2, 14.1, 15.2	......
A	9	3.1, 4.2, 7.1, 8.2, 11.1, 12.2, 15.1, 16.2, 19.2	6,500
B	10	1.2, 2.3, 4.1, 5.2, 8.1, 9.2, 12.1, 13.2, 16.1, 17.2	13,000
C	10	1.1, 2 2, 3.3, 5.1, 6.2, 9.1, 10.2, 13.1, 14.2, 18.2	19,500

After staking out of plots sand was applied, harrowed in, and then the land was furrowed out and planted.

Fertilization to be uniform to all plots.

Experiment planned and laid out by R. S. Thurston.

Experiment harvested, J. H. Midkiff.

J. A. V.

The Status of Lime in Soil Improvement.*

By Elmer O. Fippin.

The use of lime on the soil is shown by practical experience to be needed by such large areas and the scientific questions involved with its correct and economical use are revealed to be of such complicated and far-reaching character that the further investigation of this subject is a matter of major importance in crop production and soil improvement.

The underlying scientific reasons for this need for lime and the functions performed by it in the soil and in the plant are still matters of wide differences of opinion among investigators. This discussion ranges over the questions: Is there free acidity in the soil? What is the relation of free acid to the lime or other base-absorption coefficient of the soil? What tests, if any, constitute an adequate measure of the need for lime by a particular soil for the growth of so-called acid-sensitive crops? Is free acidity in itself the limiting factor or is it correlated with some other condition which is responsible for the character of plant growth, such as the presence of aluminum nitrate?

The opinion is quite general among investigators that the need for lime is associated either in a direct or an indirect way with an acid condition of the soil as measured by the absorption of a base, upon which principle rests most of the methods of measuring the need for lime.

The Use of Lime Materials in the Soil.

Concerning the range of tolerance by different crops of an acid condition of the soil, very little is definitely known, but a wide variation is indicated, for example, by the distinctions between alfalfa and blueberries or red sorrel and red clover. The sorrel plant (12, 14)[1] illustrates a further fact, namely, that some plants have a wide range of tolerance of both an acid and a lime-rich condition of soil, while other plants may have a narrow range of tolerance.

The range of tolerance of microscopic plants such as those concerned with the transformation of nitrogen and those concerned with the production of a diseased condition of plants, such as the potato scab (5) and the club root of cabbage, is equally important from the viewpoint of farm practice. The lack of accurate information concernnig the tolerance of the lower plant forms is equally as great as it is concerning the higher plants. Certain it is that plants cannot be divided sharply into two classes, one of which will thrive only on an alakaline soil while the other will thrive only on an acid soil. We believe that every graduation of tolerance is exhibited among different plants. Herein arises another important point.

Too often it has been assumed that for plants that thrive on a soil near the

* Presented at the twelfth annual meeting of the American Society of Agronomy Chicago, Ill., November 10, 1919, and reprinted in Journal of the American Society of Agronomy, April, 1920.

1 Reference is to "Literature cited," p. 79.

neutral point too much lime carbonate could not be present in the soil. The question might very properly be asked whether the alkaline or calcium-magnesium tolerance of plants may not be quite as important to determine as their tolerance of the opposite or so-called acid condition.

The investigations of Fred[2] of Wisconsin, the studies of chlorosis (4) or inability to absorb iron in certain lime-rich soils in Florida, and field observations by the writer and others point to the importance of this subject.

Effects of Lime on Soil.

Coming now to the use of lime on the soil, including both the caustic and the carbonate forms, two classes of problems arise, namely, (*a*) What are the relative effects of equal amounts of the oxides of calcium and magnesium on the chemical, physical, and biological properties of the soil? and (*b*) What are the relative practical aspects of the use of these different materials?

Several investigations are in progress on the effect of liming materials on the chemical nature of the soil and the soil solution, under laboratory, plat, and field conditions. These have not reached a conclusive stage, as is illustrated by the data on the relation of lime to the availability of phosphorus and to a less extent of potassium (1, 3). Equally undetermined is the ultimate relation of lime to the store of nitrogen in the soil, especially when its use is combined with the growth of a legume.

Much misinformation has been given out on the effect of different forms of lime on the disappearance of organic matter from the soil. Here, distinction has not been made between purely chemical effects of the lime compound on the organic matter and the biological effects resulting from the stimulation of the growth of microorganisms in the soil by lime materials. The growth of such organisms is inevitably at the expense of the organic matter in the soil. To what extent is this effect necessary and legitimate and to what extent may it be undesirable? Is it a similar effect for both carbonate and caustic forms of lime?

The statement, common in the older agricultural literature (8), that caustic lime applied to the soil in even reasonable amounts is especially destructive of organic matter, has usually been put in form to indicate that this destruction is a purely chemical process, such as occurs when spontaneous combustion of inflammable material results from the contract of a large amount of water with a considerable quantity of quick lime. This idea of the destruction of organic matter has extended to hydrated lime, because it also has caustic properties, but it has no capacity for chemical union with water involving the liberation of heat. Further, the slacking of lime in the soil, say as granular quick lime, cannot result in the rise of temperature necessary to a destructive chemical change. Unquestionably there is chemical union of the lime with constituents of the organic matter. That this union is truly destructive of the organic substance, as would be indicated by the liberation, even in strongly alkaline solutions, of carbon dioxide, has not been demonstrated and the phenomena are not in accord with the known principles of organic chemistry.

[2] Personal communication to the writer.

The chemical and biological relations of this problem must be kept clearly separated. If organic matter decomposes more rapidly where caustic forms of lime have been used than where carbonate forms have been applied, as is frequently claimed, it raises the question whether, as a result of these more active chemical and biological reactions, the use of caustic forms of lime in suitable amounts may be better than the use of carbonate forms. Who can say what are the relative effects of caustic and carbonate forms of lime on the granulation and on the porosity and related properties of different soils? Are these effects the same or do they vary with different kinds of soil? Available data indicate that in any direct way caustic forms of lime have the largest granulating effect (2) on clay soils, while carbonate forms are either nearly inactive or produce positively an unfavorable physical change. Do the available data on this point furnish an adequate guide?

Closely connected here is the question of how long caustic lime remains in the hydrated form in the soil, and into what new combinations either the caustic or carbonate form enters in the soil. MacIntire (11) and Mooers of the Tennessee station have done much work showing, first, that caustic forms of lime are not chemically destructive of organic matter; second, that recarbonation proceeds very rapidly and is normally completed in a few days at the outside; and third, that magnesium and to a less degree high calcium limes rapidly enter in silicate combinations and that these new combinations markedly affect the solubility and movement of those constituents in the soil. Especially does the magnesium seem to increase the movement of sulphur. Conner[3] of Indiana has data showing that calcium in silicate combination, as in basic slag, may be nearly as effective in performing the functions of lime in the soil as when applied in caustic or carbonate form.

Forms and Fineness.

This matter of the value of lime in certain types of silicate and similar combinations is particularly important because it is related to the matter of fineness of lime materials applied to the soil. If lime in these silicate forms of combination is just as effective in affecting the yield of crops as if it were in carbonate form, it is then quite permissible to apply those forms of lime that enter most actively into these new combinations, namely, burnt lime and finely pulverized carbonate, as to use the more inactive coarse carbonate. There may even be an advantage from the formation of these silicates because, first, they suggest the precipitation of colloidal silicates; second, they maintain a more mild alkalinity; and third, they aid in conserving the lime materials in the soil without interfering with their usefulness.

Growing out of this same question of form and fineness is the question of the movement of lime through the soil and the possibility of loss from leaching. The lysimeter data (10) collected at Cornell University during five years do not show any increase in loss of calcium and magnesium when lime is applied. These short-period data are vitiated by the existence of a large amount of limestone in the deep subsoil, which would tend to mask any movement from the surface

[3] Personal communication to the writer.

soil. MacIntire has found the leaching of lime through a deep section of soil to be essentially independent of the rate of application in any ordinary period of a few years. Let it be noted here that we are not concerned with what may happen in a thousand years, but with what is the practical loss from the vertical soil section that will occur in three, five, or ten years, which is as long a period as the application of lime is intended to cover.

The analysis of the soil of one of the fields at Rothamsted (6) shows the presence of as much as 3.3 per cent of carbonate of lime in the surface 9 inches and none in the second 9 inches. This carbonate of lime seems to be the result of application of chalk so long ago that the record is lost. Its persistence in the soil and the lack of movement into the subsoil indicate how slow is the movement of lime materials.

We come now to the question of suitable fineness of limestone. We have largely disposed of the question of extreme fineness. The next question here is, how large may particles of lime carbonate be and still perform the full functions of such material in the period for which it is applied, namely, from three to six years or for an average rotation? First of all, let us be reminded that certain processes in the soil are inhibited, as compared with their operation in a free liquid. This is especially true of diffusion. Lime carbonate is soluble in an acid solution, and will continue to dissolve as long as the acid is present in contact with the material. In the soil, the question arises, through how wide an area of soil does diffusion operate when this soil is in the optimum moisture condition? From most of the investigations available it seems to be very slow, and to reach a very short distance from the point of solution. If there is more lime in a particle than is required to neutralize the acid solution or satisfy the lime-absorption coefficient of the soil within the active range of the surface of the lime particle, then at the end of this reaction the remainder of the particle of lime will be essentially sealed in a shell of the alkaline soil where it may remain for a long period except as it is disturbed by mechanical means. How coarse may a particle be before this condition occurs in the average acid soil? Is the maximum size of such a particle as large as one-fourth or one-tenth of an inch in diameter, or is it down around one-fiftieth to one-eightieth of an inch in diameter? The practical data on this point are very meager. Observations on calcareous glacial soils reveal particles of carbonate of lime in soils the greater part of which are distinctly acid to litmus and which respond with larger crop growth where lime is applied. Experimental field data (7, 9, 13, 15) are available for so short a period or have been secured under such conditions of soil, crop succession, and rate of application as to make them of questionable value as a guide in this practical matter. Certain it is that such studies are not adequately conducted unless four conditions are met:

1. The soil must be distinctly in need of lime throughout a vertical section at least 4 feet deep from the surface.

2. The limestone must be sorted into rather narrow textual divisions and used in oxide-equivalent amounts.

3. The rates of application should range from a very small quantity, such as 200 or 300 pounds, up to as large a quantity as several tons.

4. The crop should be one sensitive to an acid soil condition and one not able to succeed in that soil without lime.

A fifth condition may be added, namely, insurance that there is an adequate supply of nutrients such as phosphorus. The question of suitable fineness cannot be regarded as settled in any sense, nor is it sufficient to advise the use of a large quantity of coarsely ground material on the chance that there may be enough fine material to supply the needs of the soil for good plant growth. This runs into economic questions A further point involved is the extent to which the time element may compensate for lack of fineness.

Field Experiments at the Present Time.

Almost none of the field experiments involving the study of lime materials is designed in a way adequately to investigate any one or more of the important scientific and practical problems involved in the use of liming materials on the soil. Certainly no adequate data of that sort have accumulated This is not meant to cast any undue reflection on such carefully maintained or long continued work as that at the Ohio, Pennsylvania, and other stations. In the planning of those experiments the natural human limitation attaching to the investigations in a new field has been involved.

Relation of Form of Lime to the Type of Soil.

The questions of caustic vs. carbonate lime, fine vs. coarse lime, calcium vs. magnesium, and the amount of lime necessary for particular crops have not been settled by scientific investigations and for the guidance of practice must rest largely on the empirical results of field trials. Such empirical or practical field data as well as real experimental work should include results obtained on a number of types of soil. It is not safe to draw conclusions from results on a single type of soil.

Finally, the practical aspects of these questions are embodied in laws covering the sale of liming materials, which are now widely divergent in procedure and requirements, and reflect the unsettled state of the general knowledge on the subject. Certainly, the essential elements of a lime-inspection law must be very much the same in the different States. If it is oxides of calcium and magnesium with which the farmer is concerned, then the first step would seem to be to report all forms of liming materials, both carbonate and caustic, on the basis of their oxide content. If fineness is a factor in value, then the fineness of carbonate materials should be reported for a standard series of screens ranging in size from the coarsest material that has appreciable value down to as fine materials as seems to be of importance under field conditions. The United States Bureau of Standards has recently promulgated a new system of specifications for testing screens, and all provisions for screen analysis should be in harmony with these specifications and uniform among the different States.

I hope that the information, energy, and facilities of all the workers in the field of soil and crop improvement may be pooled in some kind of a broad conference to study all these questions, and as rapidly as possible to standardize our information and practices with reference to the use of lime in soil.

Literature Cited.

1. Briggs, L. J., and Breazeale, J. F. Availability of potash in certain orthoclase-bearing soils as affected by lime and gypsum. *In* Jour. Agr. Research, v. 8, no. 1, p. 21–28. 1917.
2. Fippin, Elmer O. Some causes of soil granulation. *In* Proc. Amer. Soc. Agron., v. 2 (1910), p. 106–121. 1911.
3. Gaither, E. W. Effect of lime upon the solubility of soil constituents. *In* Jour. Indus. and Engin. Chem., v. 2, no. 7, p. 315, 316. 1910.
4. Gile, P. L. Relation of calcareous soils to pineapple chlorosis. Porto Rico Agr. Expt. Sta. Bul. 11. 1911.
5. Gillespie, Louis J., and Hurst, Lewis A. Hydrogen-ion concentration—soil type—common potato scab. *In* Soil Sci., v. 6, no. 3, p. 219–236. 1918.
6. Hall, A. D. Book of the Rothamsted Experiments, 2d ed., p. 140. E. P. Dutton & Co. 1917.
7. Hartwell, B. L., and Damon, S. C. A field comparison of hydrated lime with limestone of different degrees of fineness. R. I. Agr. Expt. Sta. Bul. 180. 1919.
8. Hopkins, C. G. Soil Fertility and Permanent Agriculture, p. 162. Ginn & Co. 1910.
9. ——, Garrett, F. W., Whitchurch, J. E., and Fahrnkopf, H. F. T. Illinois crop yields from soil experiment fields. Ill. Agr. Expt. Sta. Bul. 219. 1919.
10. Lyon, T. L., and Bizzell, J. A. Lysimeter experiments. N. Y. (Cornell) Agr. Expt. Sta. Memoir 12. 1918.
11. MacIntire, W. H. The carbonation of burnt lime in soils. *In* Soil Sci., v. 7, no. 5, p. 423–436. 1919.
12. Pipal, F. J. Red sorrel (*Rumex acetosella*) and its control. Ind. Agr. Expt. Sta. Bul. 197. 1916.
13. Stewart, R., and Wyatt, F. A. The comparative value of various forms of limestone. *In* Soil Sci., v. 7, no. 4, p. 273–278. 1919.
14. White, J. W. Concerning the growth and composition of clover and sorrel (*Rumex acetosella*) as influenced by varied amounts of limestone. *In* Ann. Rept. Pa. State College for 1913–14, part 2, p. 46–64. 1915.
15. The maintenance of soil fertility; a quarter century's work with manure and fertilizers. Ohio Agr. Expt. Sta. Bul. 336. 1919.

[W. P. A.]

Effect of the Relative Length of Day and Night and Other Factors of the Environment on Growth and Reproduction in Plants.

Messrs. W. W. Garner and H. A. Allard[1] have shown that relative length of day and night has been found to exert a remarkable influence on growth and reproduction in a number of different plants which have been studied. The work was done near Washington, D. C., where the summer days are long. Plants were grown in wooden boxes, galvanized iron buckets, or ordinary flower pots, depending on the size and growth habits of the species in question. Test plants were placed in a dark house for a portion of each day, while controls were kept outside and exposed to the full day period of illumina-

[1] "Journal of Agricultural Research," Vol. XVIII, No. 11, Washington, D. C., March 1, 1920.

tion. Most test plants were exposed to light for five, seven or twelve hours daily. Those exposed for five hours were taken from the dark house at 10 A. M. and returned to the dark house at 3 P. M. daily. Those exposed for seven hours were taken from the dark house at 9 A. M. and returned at 4 P. M., while those exposed for twelve hours were taken out at 6 A. M. and returned at 6 P. M.

Soybeans, tobacco, wild asters, beans, carrots, lettuce, radishes, and a number of other plants were tested. It was found that each species, and, in fact, each variety, can attain the flowering and fruiting stage only when the length of the day falls within certain limits. Rate of vegetative growth is directly proportional to the length of the daily exposure to light. Light intensity within certain broad limits does not seem to be a factor of much importance. How greatly the rate of growth may be influenced by shortening the daily period of illumination may be seen from the following table, which summarizes some of the results obtained with four varieties of soybeans. The heights given in the table are based on measurements of twenty to twenty-five plants in each case.

TABLE SHOWING HOW GROWTH OF SOYBEANS IS CHECKED BY SHORTENING DAILY PERIOD OF ILLUMINATION

Variety	Duration of Test	Height of Plants Illuminated for:			
		5 Hours Daily	7 Hours Daily	12 Hours Daily	Full Day
Mandarin	May 20 to June 15	6–7 in.	....	....	18–20 in.
Mandarin	May 20 to June 15	....	9–10 in.	....	19–20 in.
Mandarin	June 11 to July 21	....	....	14–15 in.	32–33 in.
Peking	May 20 to July 21	5–6 in.	....	....	42–43 in.
Peking	May 20 to July 21	....	8 in.	....	45–48 in.
Peking	June 11 to Aug. 6	....	....	14–15 in.	39–40 in.
Tokyo	May 20 to July 29	7–8 in.	....	....	49–50 in.
Tokyo	May 20 to July 29	....	7–8 in.	....	49–50 in.
Tokyo	June 11 to Aug. 21	....	....	17–18 in.	42–43 in.
Biloxi	May 20 to Sept. 4	6–7 in.	....	....	57–58 in.
Biloxi	May 20 to Sept. 4	....	11 in.	....	57–58 in.
Biloxi	June 11 to Sept. 8	....	....	23–24 in.	54–55 in.

It will be seen from the table that shortening the natural period of illumination, and thereby the working day of the soybean plant, greatly reduces its rate of growth.

The variety Mandarin is early maturing; Peking, medium maturing; Tokyo, late maturing; and Biloxi, very late maturing. For plantings in the field extending through the month of May, the average number of days from germination to blossoming was approximately 27, 56, 70 and 105, respectively, for Mandarin, Peking, Tokyo and Biloxi. Under the influence of a daily exposure to light of twelve hours or less, all of these varieties became early maturing. In

other words, it seems that the reason Mandarin is an early variety, and Biloxi a very late variety, is to be found in the fact that Mandarin attains the reproductive stage under a long daily period of illumination, while for Biloxi a short daily period of illumination is necessary before it will blossom. Mandarin comes to blossom during the long days of June and July. The short days of September are required to bring Biloxi to flower. If the length of day is artificially shortened, Biloxi also will blossom during June and July.

The other plants studied gave similar results. It seeems that sexual reproduction can be attained by plants only when they are exposed to a specifically favorable length of day. It is thought that relative length of day through the year is an important factor in determining whether many plants behave as annuals, biennials, or perennials. It is also thought to be an important factor in determining the natural distribution of plants. The effect of the relative length of day on the time of blossoming of cultivated plants is an important factor in crop yields. It emphasizes the importance of seeding at the proper time.

[L. O. K.]

Notes on Double Polarization Methods for the Determination of Sucrose and a Suggested New Method.*

By Geo. W. Rolfe and L. F. Hoyt.

The well-known principles and methods of double polarization applied in the analysis of commercial sugar products need not be detailed here. The methods in use depend on the assumption that the change in optical rotation of a sugar solution, which is the measure of the sucrose, is the result of the inversion of the sucrose only. One of the chief objections to the original method of Clerget and Herzfeld arises from the fact that the direct reading is made on a practically neutral solution and the invert reading on a strongly acidulated one. Much work has been done in developing improved methods of procedure to prevent or at least mitigate the errors which are introduced under these conditions, especially in sugar estimations of low-grade products where the change in acidity causes changes in the optical rotation of the sugars, other than sucrose, which are present. Those who are interested in these investigations may be referred to the voluminous and familiar papers of Pellet, Sidersky, Anderlik, and others. As the field has by no means been exhausted, even so far as to develop methods which really meet many of the requirements of commercial analysis and general research, the present paper is published as suggestive of a new line of attack of the problem.

In making up the solutions two lots of commercial granulated sugar were

* Journal of Industrial and Engineering Chemistry, March, 1920.

used—one from the Standard Refinery of Boston, polarizing 99.95 and the other from the Revere Refinery, polarizing 99.99. The factors of inversion for these sugars were obtained by the Clerget method, modified by carrying out the inversion at room temperature, and by the method of Herzfeld, likewise modified. Table I gives these factors (see also Table II).

TABLE I.

Method	Sugar Used.	Time	Temperature ° C.	Factor
Clerget	Standard Granulated	22.0	23	144.56
	Revere Granulated	22.0	28	144.17
			Average	144.37
Herzfeld	Standard Granulated	21.5	28	142.43
	Revere Granulated	21.5	28	142.67
			Average	142.56

It is well known that the factor obtained by the invertase method of Hudson is much lower than that obtained by the Clerget and similar procedures, and it is also known that this is caused by the fact that the acid augments the invert reading. What does not seem to be so well known, if it has been published at all, is that *neutralized* acid-inverted solutions give larger readings than the original acid solutions. Apparently neutralization does not affect the increase in rotation caused by the acid, but the reading is still further increased by the salts formed in neutralization as shown in Table II.

TABLE II.

(Method of Herzfeld.)

Test.	Factor for Acid Solution.	Factor for Neutralized Solution.	Difference.
1	142.43	143.30	0.87
2	142.69	143.39	0.70
3	142.66	143.41	0.75
		Average	0.77

An invert-sugar solution, made by heating a $N/2$ (saccharimetric) sucrose solution with 0.01 normal hydrochloric acid on a boiling water bath for 30 min., gave the factor 141.7, agreeing with that given by Browne for a neutral solution, as was to be expected, since the acidity was negligible. Adding hydrochloric acid in the proportion used in the Herzfeld method increased the reading by —1.35. Addition of the equivalent amount of sodium hydroxide to produce a neutral solution, gave a further increase of —0.60.

Some work was done with the modification of Anderlik, in which urea is used as a retardant of the inversion when the direct reading is made in the presence of the usual amount of hydrochloric acid. Our experience with this method on cane products was unsatisfactory, as the direct polarization changed rapidly and indeed was quite unmanageable when the temperature approached 26°. This method, therefore, would be inapplicable in raw-sugar work in the tropics,

however satisfactory it may be for low-grade beet products. Our tabulated results, which are not given here since the method has already been adversely criticized by Browne and others, show that unless the direct polarization is completed in less than 3 min. the error from inversion change is too great to be negligible. Glycocoll as a substitute for urea proved still more unsatisfactory.

Inversions With Mono- and Trichloroacetic Acid.

It seemed desirable to find a substitute for hydrochloric acid which would invert so slowly at ordinary temperatures as to permit direct readings without error, and yet be sufficiently acid to effect complete inversion upon convenient heat treatment. Accordingly, the following investigations were made with mono- and trichloroacetic acids, which had the great advantage of giving no troublesome precipitate with the soluble lead salts which were left after clarifying. The affinity constant of trichloroacetic acid is given as 75.4 and that of monochloroacetic acid as 4.8 on the basis of $HCl = 100$.

TABLE III.
Direct Saccharimeter Reading.

With 0.5 G. Trichloroacetic Acid.			With 0.5 G. Monochloroacetic Acid.	
Time Min.	Reading.	Temperature °C.	Time Min.	Reading.
3	50.00	19.2	5	50.00
5	50.00	19.3	6	50.00
7	50.00	19.4	8	50.00
10	50.00	19.6	10	50.00
15	50.00	19.3	15	50.00
20	49.90	20.4	20	50.00
30	49.75	20.6	30	50.00
40	49.70	20.9	45	49.85
60	49.55	21.4	60	49.80
90	49.30	21.6	25 hrs.	47.50

(13.0 g. of sucrose in 100 cc.)

The first series of experiments (Table III) was to determine the rates and factors of inversion at ordinary temperatures of half (sugar) normal solutions of sucrose containing 0.5 g. of mono- and trichloroacetic acids, respectively. These two solutions were heated in stoppered flasks for 30 min. in a boiling water bath, and inverted smoothly without discoloration, giving constants of 142.2 in both cases.

These inversions of pure sucrose solutions of commercial concentration promised a satisfactory method, but Tolman's observations on citric acid inversions have shown that soluble acetates have a marked inhibitory effect. It was calculated that 1 cc. of lead acetate (sp. gr. 1.26) would leave soluble acetate equivalent to 0.125 g. of sodium acetate. A half (sugar) normal solution of sucrose was therefore made up with 0.5 g. of monochloroacetic acid and 0.625 g. of sodium acetate, the latter equivalent to 5 cc. of lead acetate, which was considered the maximum for all ordinary commercial polarizations. It was found that acetate in this amount retarded inversion in the cold to such an extent that

there was no change in the direct reading for several hours, and even 30 min. treatment at 100° gave only 15 per cent inversion. The retarding influence of the soluble acetate could be overcome by increasing the amount of chloroacetic acid, but in the case of trichloroacetic acid this was not practicable because, if enough acid was used to complete the inversion of a $N/2$ solution, it gave a reading of 49.90 after only 4 min. in the cold.

Two grams of the trichloro-acid in the presence of 0.625 g. of soluble acetate caused an inversion of only 94.3 per cent in 30 min., 3 g. being necessary for complete inversion.

With the soluble acetate omitted, 3 g. of trichloroacetic acid accelerated the inversion in the cold as shown.

$N/2$ solution, polarizing 50.00.	
At end of 5 min....................	49.85
At end of 10 min....................	49.75
At end of 25 min....................	49.60

Furthermore, the trichloroacetic acid, decomposing in the water bath, frequently gave off so much chloroform vapor as to burst the flasks. With monochloroacetic acid there is a slight depression of the polarization caused by the addition of the acid and acetate, as a similar $N/2$ sugar solution at the end of 2 min. gave a reading of 49.85 which remained constant through observations of a few minute intervals carried on for over an hour.

A sample of Cuban sugar, clarified with 2 cc. standard basic lead acetate solution per $N/2$ weight and treated with 3 g. of monochloroacetic acid, gave a constant polarization for over an hour.

TABLE IV—EFFECT OF ACETATES ON INVERSION FACTOR OF A $N/2$ (SACCHARIMETRIC) SOLUTION OF SUCROSE INVERTED BY 3 G. OF MONOCHLOROACETIC ACID AT 100° C.

Sodium Acetate per 100 Cc. G.	Time of Heating Min.	Average Value Inversion Factor	No. of Observations.
None	30	141.02	10
0.0625	30	141.00	5
0.125	30	141.05	4
0.325	30	141.10	1
0.500	30	141.00	5
0.625	30	140.32	1
0.625	60	141.06	3

To test the effect of an excess of lead acetate clarifier, a $N/2$ sucrose solution to which had been added 1 cc. of lead acetate clarifier, 0.5 g. of sodium acetate, and 3 g. of monochloroacetic acid, was found to resist inversion for 30 min. in the cold but inverted smoothly in the boiling water bath in 30 min. with no signs of discoloration, the inversion factor being identical with that of a lead-free solution similarly treated. Table IV shows the influence of varying amounts of sodium acetate on the inversion factor obtained with monochloroacetic acid. It will be seen that the inversion is incomplete after 30 min. boiling in the presence of more than 0.500 g. of soluble acetate.

To test the effect of sodium chloride two inversions with monochloroacetic acid were made in the way described in the above series, one with 0.625 g. of acetate and 0.65 g. of sodium chloride, the other with 0.65 g. of sodium chloride only. The factors obtained were 141.04 and 141.08, respectively. showing that a sodium chloride content up to 5 per cent of the weight of the sample does not affect the inversion.

Whenever sugar solutions are inverted at a high temperature with hydrochloric or monochloroacetic acid there is a noticeable lag in the polarization even after the solution has reached temperature equilibrium with that of the saccharimeter, the constant reading being always (numerically) greater than the initial. This lag, usually lasting but a few minutes, has been repeatedly noticed in solutions treated by the Clerget and Herzfeld methods, and is greater the less the acid content. When $N/100$ HCl was used the initial polarizations were as much as two divisions lower numerically than the final constant value. With chloroacetic acids the lag is smaller but it lasts longer (Table V). The possible causes of this lag will not be discussed at this time.

TABLE V—LAG OF POLARIZATION OF VARIOUS INVERTED SUGAR SOLUTIONS.

A			B			C		
Time Min.	Reading.	Temp. Deg.	Time Min.	Reading.	Temp. Deg.	Time Min.	Reading.	Temp. Deg.
6	11.50	18.6	7	13.50	19.8	5	12.00	19.4
7	12.20	18.8	8	13.90	19.8	6	12.75	19.5
9	13.00	19.7	9	14.30	20.0	8	13.60	20.0
10	13.15	20.2	10	14.50	20.3	10	14.20	20.4
12.5	13.50	21.0	12	14.70	20.8	15	14.85	20.8
15	13.80	21.4	15	14.85	21.3	20	14.95	21.2
30	14.15	21.4	20	14.90	21.6	30	14.85	21.7
60	14.40	23.2	30	14.80	22.0	100	15.35	22.0
			Hrs.			Hrs.		
75	14.30	23.0	20	15.85	20.0	18	16.10	20.0
100	14.00							
Hrs.								
20	15.20							

D			E		
Time Min.	Reading.	Temp. Deg.	Time Min.	Reading.	Temp. Deg.
6	13.60	22.1	3	12.70	21.4
10	14.10	22.4	4	13.25	21.5
15	14.30	22.4	5	13.55	21.7
27	14.85	22.6	7	14.05	22.2
40	14.70	23.6	14	14.35	22.6
Hrs.					
23	15.80	20.0	25	14.50	23.2
			40	14.50	23.5
			Hrs.		
			2.25	14.50	23.5
			4	15.10	23.6
			24	15.76	20.0

A—$N/2$ Sucrose solution inverted by 0.01 per cent HCl at 100°.
B—$N/2$ Sucrose solution inverted by 0.01 normal HCl at 100°.
C—$N/2$ Sucrose solution inverted by 0.5 g. trichloroacetic acid at 100°.
D—$N/2$ Sucrose solution inverted by 3 g. monochloroacetic acid with 0.625 g. of $NaC_2H_3O_2$.
E—$N/2$ Sucrose solution inverted by 3 g. monochloroacetic acid and 0.625 g. of $NaC_2H_3O_2$.

The factor 141.0 has been adopted as correct for a monochloroacetic acid inversion, and is based on the series of inversions of pure sucrose shown in Table VI. The 60 min. inversions showed some decomposition, as indicated by the lower factor. If, however, low-grade products, requiring as much as 5 cc. of clarifier, are inverted, the time should be increased to 1 hr., owing to the retarding influence of the soluble acetates. This is made clear in Table IV.

TABLE VI—DETERMINATION OF INVERSION FACTORS BY THE MONOCHLOROACETIC ACID METHOD.

	15 Min.	30 Min.	60 Min.
	141.60	141.14	140.30
	140.08	140.92	140.38
	141.20	140.90	140.40
	140.98	140.90	140.20
	141.16	141.00	.....
Average ...	141.20	140.97	140.32

To compare this method with the invertase method of Hudson, accepted as the standard method for accurate results, an invertase solution was prepared from compressed yeast. Half-normal sugar solutions were inverted at about 30 C. with varying amounts of this solution. The results are given in Table VII.

TABLE VII—INVERSION CONSTANTS BY INVERTASE METHOD OF HUDSON.

Time of Inversion.	Factors for Volume of Invertase Solution Used.		
Hrs.	5 cc.	7.5 cc.	10 cc.
21	140.46	141.54	141.68
45	141.54	141.34	141.72
70	141.70	141.72	.....

Time permitted only comparative tests by the invertase, Herzfeld and monochloroacetic methods on two samples of Cuba seconds and one of refinery barrel syrup. In the invertase tests the solutions were carefully "deleaded" according to directions by Browne.[1] In the other tests the minimum amount of basic lead acetate to clarify was used. Table VIII shows the comparative results by the three methods, making it clear that the monochloroacetic acid method gives results much closer to those obtained by the standard invertase method than does the Herzfeld method.

[1] "Handbook of Sugar Analysis," p. 276.

TABLE VIII.

A—Comparison of Double Polarization Methods.

Sample.	Method.	Direct Polarization.	Concentration of Solution.	Invert Polarization. (All Readings in $N/2$ Solution.)	Factor Used.	Per Cent of Sucrose.
Cuban Second Sugar No. 1438	Invertase	88.01	N	—14.10	141.70	88.24
	Monochloroacetic	44.44	$N/2$	—13.51	141.00	88.45
	Herzfeld	89.01	N	—14.38	142.66	88.63
Cuban Second Sugar No. 1323	Invertase	88.40	N	—11.18	141.70	84.08
	Monochloroacetic	44.00	$N/2$	—11.26	141.00	84.36
	Herzfeld	88.23	N	—12.16	142.66	85.04
Barrel Syrup from Am. Sugar Refinery	Invertase	34.63	N	—6.65	141.70	36.35
	Monochloroacetic	17.39	$N/2$	—6.46	141.00	36.41
	Herzfeld	35.02	N	—6.93	142.66	36.85

B—Percentage Difference between Per Cent of Sucrose by Three Methods.

Sample.	Monochloroacetic minus Invertase.	Herzfeld minus Invertase.	Herzfeld minus Monochloroacetic
Cuban Second No. 1438	0.21	0.39	0.18
Cuban Second No. 1323	0.28	0.96	0.68
Barrel Syrup	0.06	0.50	0.44

The effect of the monochloroacetic acid method on commercial glucose readings was briefly investigated.

Many analysists do not realize that commercial glucose is not a well-defined chemical compound, but may vary considerably in composition and physical characteristics. The average glucose of today is considerably lower converted than that of a few years ago, so that the Ventzke reading of 175 for the (sucrose) normal weight under standard conditions of polarizing is too low. In fact, the sample of glucose used in the present investigation showed a Ventzke reading of 177.85.

TABLE IX—EFFECT OF MONOCHLOROACETIC ACID ON COMMERCIAL GLUCOSE READINGS IN DOUBLE POLARIZATION METHOD.

Test Made.	Readings with No Acid.	Readings with 3 g. Monochloroacetic Acid.	Difference.	Total Difference.
Before heating	(*a*) 88.70	(*b*) 88.10	$(a-b) = 0.60$	1.89
After heating	88.09	(*c*) 86.81	$(b-c) = 1.27$	....
Before heating	(*a*) 88.49	(*b*) 88.05	$(a-b) = 0.44$	1.9[illegible]
After heating	88.50	(*c*) 86.85	$(b-c) = 1.50$	....
Before heating	(*a*) 88.52	(*b*) 87.98	$(a-b) = 0.54$	1.85
After heating	88.53	(*c*) 86.67	$(b-c) = 1.31$	....
				Average 1.88

Table IX shows the polarization effect of monochloroacetic acid, as used in the double polarization method described, on an approximately 10 per cent solution of this glucose.[2]

SUMMARY.

The following double polarization method is suggested as a result of these investigations. Dissolve the normal weight of sample in a 100 cc. flask, clarify with an appropriate amount of lead acetate, make up to volume and filter (the usual procedure for commercial polarizations). Transfer 50 cc. of filtrate to a 100 cc. flask, add 15 cc. of a 20 per cent solution of monochloroacetic acid, make up to volume with water, and polarize within 15 min. after adding the acid. To invert, transfer about 50 cc. of the solution to a 50 cc. flask, stopper tightly by tying down the cork, and immerse flask in boiling water, maintaining active ebullition for 30 min., or for 60 min. for low-grade products clarified with a large amount of lead acetate. Remove flask, and cool quickly to room temperature. Allow to stand at least 2 hrs. and polarize in 200 mm. tube with thermometer.

$$S = \frac{2(a-b)}{141 - \frac{t}{2}} \times 100$$

S = Per cent Sucrose.
a = Direct reading.
b = Invert reading.
t = Temperature.

All solutions should be made and polarized as nearly as possible at 20°.

The advantages of this method are:

[2] Weber and McPherson's investigations. (J. Am. Chem. Soc., 17 (1895), 312, 320.

I—Direct and invert readings are made on a solution of unchanged acidity and sugar concentration.

II—Excess of basic lead acetate, equivalent to one cc. in a half (sugar) normal solution, does not affect the inversion or produce troublesome precipitates.

III—It gives more accurate results than the Herzfeld method.

IV—Inverted solutions of low-grade products are lighter in color than those inverted by the Herzfeld method, and therefore easier to polarize.

V—No error is introduced by making up to volume after inversion.

The chief disadvantage seems to be the time required, but this is less than that required by the invertase or the more rational modifications of the Clerget and Herzfeld methods in which the inversion is carried out at room temperature, which requires at least 22 hrs. The actual time required in manipulation is little, if any, more than that taken by the usual methods.

[W. R. M.]

Recent Work of the Rothamsted Experimental Station.

By Guy R. Stewart.

There is no institution that makes a greater appeal to the interest and imagination of the agricultural worker than the Rothamsted Experimenal Station at Harpenden, England. This unique organization was founded by John Bennet Lawes, who began experiments on his estate about 1834. In 1843 systematic field experiments were commenced, and Joseph Henry Gilbert was engaged as chemist and director. He continued in his association with Sir John Lawes till his death in 1901. The relations of these two students of agriculture were wonderfully close and cordial. Together they planned the experiments which were to be carried on far into the future.

On some of the experimental plots the same scheme of planting and fertilization has been followed from 1843 to the present day. Certain rearrangements were made on a portion of the fields in 1852, but even so they are by far the oldest experiments in existence.

The Rothamsted Station has never been connected with any other organization. For a long period it was maintained entirely by Sir John Lawes. In 1889 he formed a trust for the continuance of the investigations, setting apart for that purpose the laboratory which had been built by public subscription and presented to him, the land on which the experimental tracts were located, and a trust fund of 100,000 pounds.

Since that time various private gifts have been made to the station, as well as certain grants from the Board of Agriculture, for the investigation of special problems.

The purpose of the institution has always been to study the fundamental relations of the soil and the crop. Even though its work has been planned to study the underlying scientific principles upon which agriculture is based, the Rothamsted investigations have constantly been of enormous practical value to the agriculturist.

The last triennial report, which reached us during the past year, has many suggestive items in its pages. Two-thirds of the station's staff had joined the army or entered the Government service during the early period of the war. Women were engaged to take the places of many of the men, and so the more important lines of investigation were carried on, and new emergency problems were undertaken. A long and varied list of inquiries was referred to the station by various governmental agencies. These covered reclamation schemes, fertilizer problems, utilization of waste material, and food production problems. The long time investigations were not neglected, but four major lines of work were taken up to handle the immediate questions. These groups were, (1) the economical use of manure, (2) the plowing up of grassland, (3) the control of soil organisms, and (4) the nutrition of plants. The results obtained on all these lines are of permanent interest and value for scientific agriculture.

Barnyard manure has been the most important fertilizer in Europe for many generations. It is believed that 37,000,000 tons per annum are made in Great Britain, with a cash value of at least $55,000,000. Previous work has shown that approximately half the nitrogen was ordinarily lost in storage and handling. Two causes were found to operate, namely, exposure to the weather, and deterioration from the air that penetrated into the heap.

In previous investigations, barnyard manure has been studied mainly as a source of nitrogen, but in the work carried out at Rothamsted it was found that this was too narrow a view, and that the organic matter plays an imporant part.

A considerable part of the manure heap is made up of straw, which, farmers have generally recognized, must undergo a certain amount of decomposition before the best results could be obtained. It was now found that the unchanged straw goes far to neutralize the benefits of the other fertilizing materials, and in extreme cases it may actually decrease the crop. Changes and fermentation in the cellulose and carbohydrate constituents were found to be essential to its fertilizing value.

This dependence upon manure as the principal farm fertilizer is only possible under a system of diversified farming. The most progressive American farmers have attempted to supply the nitrogen and organic matter which the English farmer obtains from manure by the use of cover crops. Excellent results have been obtained from these crops where they have been turned under in a fresh succulent state. Owing to the shortage of rainfall that often occurs in the semi-arid western states, some farmers have tried dry straw to supply organic matter. The general result has been a distinct reduction of fertility that

corroborates the Rothamsted manure experiments. It is quite possible in the Hawaiian Islands that some of the decrease in yield experienced in the drier regions, when cane trash is turned under, may, in the same way, be due to the harmful effect of the undecomposed woody tissue.

The problems connected with the breaking up of grassland, which took place in England during the war, produced a number of interesting points. Insect pests, such as wireworms, developed in astonishing numbers, so that soil sterilization by heat was found to be necessary for their control, though this was only feasible for high-priced truck crops.

The weed flora began to give immediate trouble. The land plowed up had been in grass for ten years, but careful experiments showed that the lower layers of the soil, to a depth of at least twelve inches, contained vital weed seeds. Studies were then made of land thirty years under grass, and it was found to produce a copious crop of weeds. Land sixty years in grass gave a smaller number of weeds, while land two hundred years in grass produced none at all.

Studies were also made of the losses in stored-up fertility of grassland when cultivated. Here it was found that just as with virgin soils, the greatest loss of fertility was due to the oxidization and changes caused by cultivation, and that this loss was greater than the plant food removed by the crop.

The work on problems of the soil bacteria have shown an interesting relationship between the numbers of bacteria and protozoa. It has been found that the protozoa multiply at the expense of the bacteria, and that when this was the case the soil became unhealthy for plants. Certain truck gardeh and hot house soils showed this trouble, and it was found that it could be remedied by soil sterilization.

In the field of plant nutrition, numerous papers have recently been published from the Rothamsted station. These bear directly on the fundamental relationship of the plant to the soil. They take up the concentration of the medium best suited to plant growth. Other studies present information as to the formation of carbohydrates in root crops. Cane sugar was the sugar first formed in the leaves. This was transformed into simpler sugars in order to permit its transfer to the root, and again converted into cane sugar for storage.

Reference to the future plans of the Rothamsted Station clearly show the relationship it bears to the practical problems of English agriculture. The director points out that since the farmer's task in the future will be to increase his yield, the problems connected with this will necessarily determine the program for future research work. Some of the questions that relate to wheat production are now being faced by the station. "We must strengthen the straw, improve the tillering, regulate to some extent the development of grain, and control the pests. Until these are all solved, we cannot hope to get much further with increased wheat yields."

Such a record of accomplishment and constructive planning for the future is inspiring to us, even though we do not face the varied questions of diversified farming, and are far distant from the disturbing problems of Europe.

Low-Grade Sugar Cane Molasses.*

By W. H. DALRYMPLE.[1]

There is, perhaps, no stock-feeding material that has aroused so much general interest among stockowners and feeders in this country as low-grade sugar-cane molasses, or "blackstrap." And, as inquiries concerning this material have become so numerous, from all over the country, the publication of a short article on the subject, setting forth its main features as a feed, has been deemed desirable at this time.

The term "blackstrap" is given to the low-grade uncrystallizable residue of the sugar-making, or sugar-refining, process, which at one time, in Louisiana at least, was discarded as of no economic value, and, consequently, wasted, so far as its feeding importance was concerned.

The use of molasses as an appetizer and tonic for stock has been in vogue with owners and feeders for quite a length of time, however; but as a food nutrient of the carbohydrate class, its extensive and intelligent adoption dates back only to more recent years, and it is being utilized now, not only as a regular ingredient of mixed rations on plantations and farms, but by the commercial world in the various so-called "sweet feeds" that are to be found upon the market.

It should be understood, however, that while blackstrap is a most valuable food of its class, it is not a perfectly balanced food in itself, as it supplies, in the main, only one of the nutritive elements (carbohydrates) of a mixed and balanced ration.

It is valuable for at least four very good reasons, viz.: (1) Its palatability; (2) under normal conditions, its cheapness as a source of the carbohydrate element—sugar; (3) its high carbohydrate content—approximating 53 per cent; and (4) the almost complete digestibility of its contained carbohydrates.

It is the writer's opinion that the marked success which has attended its adoption during the past number of years is almost wholly due to its palatability; its condimental effect in promoting more perfect digestion of other feeds fed with it; and the readiness with which it can be absorbed into the blood system of the animal for purposes of nutrition.

The earlier analysis of blackstrap showed a somewhat higher percentage of carbohydrates—sugar; but owing to the increased efficiency in the process of producing sugar today, the per cent of its carbohydrates has been reduced to some extent.

The following may be taken as an average of its composition at the present time:

Dry Matter	Water	Ash	Carbohydrates
%	%	%	%
77.75	22.25	8.13	53.58

Some years ago the writer addressed a questionnaire to some forty-seven

* Louisiana Planter, May 15, 1920.

[1] Director Louisiana Experiment Station.

large sugar plantation owners in Louisiana to try to obtain some more or less definite information regarding results they might have had after utilizing their blackstrap in the feeding of their work mules, the number of which approximated 4,500 head. In the replies received, practically everyone conceded to a considerable saving in the amount of his feed bills, ranging from ten to fifty per cent or more; and all seemed to refer to the marked diminution in the number of cases of dietetic troubles, such as colic, etc.; and that the health, and, therefore, the capacity of the animals for work, was very much improved.

One could scarcely wish for a higher endorsement of any food product, in the case of horses and mules at least.

The feeding of molasses is not now confined to horses and mules, however; it is being used with equal success in the feed-lot, in the dairy, in the hog-pen, etc.

From inquiries received, it would seem that some feeders, not hitherto accustomed to the use of molasses, do not appear to quite understand how it should be used to the best advantage.

Here it may be stated that its economic use would depend upon the availability and cost of other carbohydrate concentrates.

For example, if corn should be expensive, and molasses considerably cheaper, it would reduce the cost of the ration if part of the corn should be replaced by its equivalent weight of molasses, as the sugar in the latter, while not quite equal to in amount, approximates the starch in the corn, both of which have the same chemical composition. However, we do not deem it altogether advisable to make a complete substitution; but a partial substitution will frequently economize in the use of corn under high-priced conditions.

Again, it is better to feed molasses where the other ingredients of the ration are in a crushed or mealy condition so as to insure better mastication, or chewing, of the whole. When fed with whole grains alone, such as oats or corn, there is a tendency or liability on the part of the animals, especially horses or mules, to "bolt" their food without the necessary chewing of the grains.

For a well-balanced and economical ration for different classes of animals, we submit the following example:

For horses or mules weighing 1,000 lbs. doing hard work and per day:

2	lbs.	Cottonseed meal.
6	"	Cracked corn or chops.
6 or 7	"	Blackstrap.
12	"	Peavine, alfalfa, lespedeza, or any of the good leguminous hays.

[J. A. V.]

Report of the Committee of the American Chemical Society to Formulate Specifications for the Construction of a Polariscope for Laboratory Use.*

By W. D. BIGELOW, *Chairman.*

Before the committee was appointed there had been considerable correspondence among sugar chemists regarding the desiderata for a polariscope for ordinary laboratory use. The correspondents included the sugar chemists of the United States, Hawaii and Cuba, and there were several conferences in the various places among the men who could arrange to meet. The correspondence regarding this matter was available to the committee and greatly facilitated our work. It has not been possible for our committee to arrange a meeting which all members could attend and most of our consultation has been by correspondence. There has been much personal conference among individual members of the committee, however, and one conference was arranged at which five members of the committee were present. We have also had the advantage of the co-operation of manufacturers of optical instruments in this country, one of whom has made a polariscope during the last year which complies with the requirements of the committee.

General Construction. The general construction of the saccharimeter outlined in these specifications should be as simple and substantial as possible. All parts of the instrument should be easily accessible and the number of bolts and screws for holding the parts in place should be reduced to the necessary minimum.

So far as possible the instrument should have smooth, plain surfaces and be without unnecessary ornamentation. An irregular ornamented surface affords grooves and crevices for the accumulation of dirt and is not easily cleaned.

The instrument should meet the requirements of exposure to a humid tropical climate and must be constructed to withstand corrosion.

The construction of the saccharimeter, so far as possible, should be of such a type that repair parts can be furnished separately, thus obviating the expense, the delay, and the danger of shipping the entire instrument. Wherever this is not practicable manufacturers should undertake to make repairs in a satisfactory manner without undue delay.

Height. The standard height of most saccharimeters from table to center of field eyepiece is between 32 and 34 cm. This height is convenient for manipulation with the elbow of the operator resting upon the table and has found most general approval.

Mounting. The saccharimeter should be mounted upon a rigid trestle support and not upon a tripod. Instruments mounted upon tripods are unstable and easily turned out of alignment, the result being an error in the zero point.

The base of the trestle should be a solid piece of metal at least 2 cm. thick,

* **Journal of Industrial and Engineering Chemistry, May, 1920.**

the bottom edge of which can rest at all points upon the table. A base elevated above the table by supporting knobs or projections lacks rigidity and has the disadvantage of permitting cover glasses and other objects to escape underneath.

As many chemists prefer to fasten their instruments to the table, the base of the trestle should be provided with slots or screw holes to facilitate this.

Lamp Supports. The lamp end of the trestle should be designed to accommodate a strong removable bracket for the convenience of those who may wish to use it as a lamp support, thereby keeping lamp and instrument always in undisturbed alignment.

The holder of the lamp must be placed at the proper focal distance and should be adjustable. Bracket and holder should be designed so as to prevent transmission of heat to the polarizer of the instrument.

For rooms of constant temperature the lamp should be in a separate room.

Trough. The trough, or tube holder, should be of solid metal, in one piece, and sufficiently thick to prevent denting or bending under ordinary conditions of usage. The diameter of the trough at the top should be about 3 cm. and should be adjusted exactly to fit the end pieces of the observation tubes. The cross-section of the trough should be semi-circular in shape. A wedge-shaped trough does not give the necessary support to inversion tubes or other tubes of unstable equilibrium.

The length of trough should be 42 cm. This length is necessary for the accommodation of the control tube which is used for verifying the accuracy of the scale. The short 20 cm. trough does not permit the use of the control tube and is also inadequate for the polarization of sweet waters and other dilute solutions.

The base of the trough should be supported to the frame of the trestle and there should be a 2 mm. space between its ends and the rest of the instrument. This clearance allows the escape of any liquid which may be spilled in the trough and protects against warping of the trough and transmission of heat to the optical parts when polarizations are made at high temperature. The base of the trough must be parallel with the optical axis of the instrument.

The trough should be made removable for the accommodation of other forms of tube supporters or baths that may be needed in special cases. Owing to the corrosive action of solutions, which may be spilled inside the trough, the screws for fastening the trough should be on the outside.

Trough Cover. The trough should be provided with a hinged cover for excluding light. The cover should be long enough to cover the 2 mm. space between the trough and splash-glass holders, and should fold back to a horizontal position where it can be used in case of need as a receptacle for tubes.

The hinges of the cover should not be riveted. Many chemists find the trough cover an encumbrance, and for the convenience of such it should be easily removable.

For the convenience of those who use continuous, or side-filled, polarization tubes, a slotted cover should be provided as an optional accessory.

Splash Glasses. The splash glasses at the ends of the trough, for protecting prisms and wedges against dust and drops of liquid, should be mounted in holders which can be quickly removed, cleaned, and replaced without the use of

tools. Slip holders with a tension spring are most generally preferred, and they should be designed to prevent sticking.

The two holders should be as near alike as possible, at least 1.5 cm. deep and so constructed that glasses can be easily removed for cleaning. For ease of replacement when damaged, the splash glasses should be of the same size as the standard polariscope tube cover-glass.

Quartz Wedges. For a commercial saccharimeter all chemists prefer the compensating single-wedge system. The wedge should be of sufficient length to give a range of scale from —35 to 115 sugar degrees.

If quartz of sufficient optical purity to give this lower range cannot be secured, a dextro quartz plate should be provided as an accessory for use in invert polarization.

The driving mechanism of the wedge should consist of a vertical rod supported to the front of the trestle frame and provided at the bottom with a milled head about 7 cm. from the table and convenient for operation with either hand.

The spiral rack and pinion with which the driving rod connects should operate smoothly and without lost motion.

Scale. The scale should be etched upon ground glass and read by transmitted light obtained from the light source of the instrument. The design of the instrument should be such that the scale can be illuminated, when continuous or control tubes are in upright position in the trough. The range of scale should be from —35 to 115. This upper limit is necessary for those who wish to determine purities without diluting below 20° Brix.

The scale should have an adjustable double vernier, for plus and minus degrees, and should easily be read to 0.05°, to which end the magnifying power of the reading microscope should be amply large The error of scale graduation should nowhere exceed 0.05°.

The adjusting screw for moving the vernier to the zero point of the scale should operate positively in either direction. In some instruments a spring is designed to act when the adjusting screw is withdrawn. The objection to such a spring is its liability to stick and not to operate as intended.

Before shipment, the scale of each instrument should be carefully standardized at suitable intervals throughout its entire range and the standardization values should be incorporated permanently in some way upon a plate attached to the instrument.

Protection Case. Scale and wedges should be enclosed in a tight protection case to prevent deposition of dust or spattering with drops of liquid. The covering of the case should be easy to take off, when it is desired to gain access to scale or wedge, by the removal of a few fairly large-size screws. The rim of the protection case should have a covered aperture for inserting the key of the adjusting screw.

Whenever desired the front of the case should be provided with a small thermometer having a range of 10° to 40° C. and with its bulb near the quartz wedge. The thermometer should be arranged so that it can be read in a darkened compartment by light obtained from the lamp which illuminates the instrument.

Screen. The protection case should be designed to accommodate a removable screen to protect the eye which is not in use from the glare of the lamp. The screen should have a diameter of about 15 cm. at the level of the two oculars.

Analyzer. While the analyzer is one of the parts which should require least attention, there are occasions when it needs to be adjusted. It should be made fairly accessible and be provided with simple means for firmly securing the adjustment.

Light Filter. The light filter should be placed between the polarizer and light source of the instrument and should be so supported that it can be quickly thrown into the field or out without disturbing the position of the instrument.

The standard bichromate cell should consist of a glass tube 3 cm. long encased in a metal jacket with threaded ends to accommodate the screw caps for holding the glasses. The cell should have a sufficient diameter so as not to require refilling because of air bubbles during an ordinary campaign (or more than twice a year).

Many chemists desire a lightly ground glass over the aperture at the lamp end of the instrument to equalize the light. Such a glass, if properly tinted, might serve the double purpose of light filter and equalizer. As a matter of convenience the instrument should be equipped with a light filter consisting of a glass plate of the same depth of color and absorptive power as the standard light filter.

Oculars. The oculars in front of the instrument for reading field and scale should focus with a screw motion. The sliding eyepiece is objectionable, owing to the ease with which it is pushed out of adjustment by the face of the observer.

The distance from center of field eyepiece to center of scale eyepiece varies in present instruments from about 3 to 6 cm. For convenience and rapidity in reading, the interval between the two eyepieces should lie within these limits.

Field. American chemists with few exceptions prefer the customary double field with vertical semi-circular halves. The field should be of good size, sharply defined, and not obscured with the rim or halo of extraneous light, which results from improper optical construction.

Polarizer. The preferences as to polarizer are divided between the Lippich and Jellet-Cornu prisms. Many chemists, while admitting certain advantages of the Lippich polarizer, complain of its frequent disintegration along the sharp edge of the half-prism upon which the telescope is focused, the result being an imperfect or shattered field. The disruption of the half-prism may result from a jar to the instrument or it may take place from no apparent cause. More saccharimeters are made unserviceable for this reason than for any other. The difficulty of repairing the damage, owing to the extreme fragility of the parts, renders the Lippich polarizer less suited for localities which are far distant from repair shops. Many chemists, on the other hand, who admit the greater stability of a modified Jellet-Cornu prism, complain of its lower degrees of sensitiveness owing to the pronounced dividing line of the field, the result either of too thick a film of balsam between the halves of the upper part of the prism or of imperfect alignment of the polarizer. The defects peculiar to each type of prism can largely be overcome by careful manufacture. There are many stable Lippich polarizers and many Jellet-Cornu prisms that are satisfactory in sensibility.

If manufacturers can make repairs rapidly and can furnish extra interchangeable half-prisms of easy adjustment, the usefulness of the Lippich polarizer would be much widened and the majority of chemists in fairly accessible localities would probably then prefer it. For remote tropical countries where repairs are difficult and time-consuming a modification of the Jellet-Cornu prism would probably be the better type. For these reasons the type of polarizer should in great measure be left optional with the purchaser. In their manufacture of polarizing prisms manufacturers should take every precaution to insure stability and to prevent drying out and cracking of the films of balsam cement.

A very serious complaint from tropical countries is the infection of the polarizer, analyzer, and other optical parts of the instrument by molds, the mycelia of which grow over the prisms, corroding their surface and obscuring the field. Efforts to prevent infection by enclosing the parts more adequately have not proved successful. The best means of preventing the growth of molds seems to be a construction that permits of easy accessibility and removal of parts for cleaning and for placing in desiccators during periods when the saccharimeter is not used.

Mounting of Prisms. Wax, as a mounting material for prisms, has proved objectionable in warm climates on account of its softening. A mounting in cork and plaster is said to be the most satisfactory.

Half-shadow Angle. The fixed half-shadow angle of the polarizer in most saccharimeters varies from 5 to 9 angular degrees, the choice of angle by different manufacturers seeming to depend somewhat upon the length and pitch of the quartz wedge. It is probable that for general commercial purposes the half-shadow angle should fall within this range. The sensibility is greater but the intensity at the end-point is less with the smaller half-shadow angle. Recent improvements in electric stereopticon lamps with concentrated filament and high candle power make it possible for manufacturers to adapt saccharimeters to a lower half-shadow angle than was formerly the case. For a normal weight of 26 grams the fixed half-shadow angle should have a magnitude of at least 7° for the average class of sugar factory raw products. The angle may be smaller than this for colorless products. The angle may also be reduced for raw products with instruments which are adapted to a normal weight of 20 or 16.29 grams.

Chemists who work constantly with dark-colored syrups and molasses prefer a polarizer with a rather wide half-shadow angle. It would, therefore be a distinct advantage if manufacturers could supply interchangeable polarizing prisms —one with a medium half-shadow angle between 5 and 8 angular degrees and another with a higher half-shadow angle between 9 and 12 degrees.

Polarizing prisms should be mounted in metal holders which can be easily removed and inserted and the adjustment of which can be quickly and securely fixed.

The sleeve, or cover, which protects the polarizer should be easy to take off by the removal of a few fairly large-sized screws.

The standard temperature for the calibration of saccharimeters shall be 20° C. For laboratories working at a temperature materially different from

this, correction of polarizations to 20° C. may be made at discretion by any of the following methods:

1—By the use of a table of temperature corrections for each particular product.

2—By changing the normal weight.

3—By changing the capacity of the flask.

4—By changing length of normal tubes.

5—By having a scale calibrated by the manufacturer so that it is correct for the temperature desired.

With the exception of the first method these methods of correction are strictly applicable only to products which contain no other optically active constituent than sucrose. For general sugar house and food products containing several sugars, in case constant temperature polarization at 20° C. is not permissible, Method 1 gives results which are nearest to those obtained at the standard temperature.

Standard or Normal Weight.

A large majority of chemists believe that the present is a most suitable time to abandon the inaccuracies and inconveniences of previous national standards and to agree upon a saccharimetric scale which shall be accurate, convenient, and so far as possible international. From opinions expressed by leading chemists in America, England and France, it is apparently more easy to secure general agreement, in these three countries at least, upon the so-called international normal weight of 20 grams proposed in 1896 by Sidersky and Pellet. According to this standard the 100 degree point of the saccharimeter scale shall indicate the polarization of 20 grams chemically pure dry sucrose dissolved in distilled water to 100 metric cc. and polarized in a 20 cm. tube, the temperature of solution and instrument to be 20° C. and the illumination to be white light filtered through a solution of potassium bichromate of such concentration that the percentage content of the solution multiplied by the length of the layer of solution in centimeters is equal to nine.

While many chemists believe that all saccharimeters hereafter manufactured for American use should be graduated solely according to this proposed international standard, it is the opinion of this committee that pending international agreement upon the question manufacturers of saccharimeters should standardize their instruments according to the scale desired by the individual purchaser.

In the adoption of an international saccharimeter standard this committee believes that—in order to avoid the numerous unfortunate changes which in the past have characterized previous standards, and in order to have absolute accuracy and uniformity in different parts of the world—the percentage content, specific gravity, refractive index and angular rotation of the normal sugar solution, and the angular rotation, in terms of sodium and mercury monochromatic light, of the quartz plate, which shall read 100 upon the saccharimeter scale, should be established by carefully conducted experiments in the governmental laboratories of the different countries; and that from the results thus found international agreement shall be reached in regard to the final values, upon which

manufacturers shall base the standardization of their instruments. The U. S. Bureau of Standards has already completed investigations upon the rotation values and other constants of the 26 and 20 gram normal sugar solutions.

It is not intended that the establishment of an international normal weight shall throw out of use the large number of saccharimeters which are at present doing excellent service. The transition is to take place gradually as in the change from Mohr to metric cc. Old instruments as they wear out are to be replaced by instruments with the new scale. Owners can also have their old instruments rescaled, but this should be done only when the accommodation of scale, polarizer, lenses, etc., secures an equal or greater accuracy in reading. If an old instrument is not rescaled it should at least be standardized and the weight of pure sucrose necessary to read 100 upon its scale be engraved or stamped upon a plate attached to the instrument. Correction of instruments by the adjustment of an incorrect scale to a correctly standardized quartz plate is open to criticism, as a scale thus adjusted is accurate only for the reading of the plate and a considerable error may be introduced at other points of the scale, especially when readings have to be corrected for dilution. [R. S. N.]

Effect of Varying the Amount of Inoculum and Concentration on the Deterioration of Sugar by Molds.*

By Nicholas Kopeloff.[1]

In a previous paper[2] it was shown that a decrease in concentration of films of known concentration in laboratory-made sugars was responsible for an increase in deterioration when heavily inoculated with mold spores. The industrial application of this conclusion is determined by two important variable factors, namely, the concentration of the films surrounding the sugar crystals, and the degree of infection. Therefore, a further investigation of the influence of these factors was considered necessary.

The method of procedure was identical with that outlined in the previous article, except that the incubation period was 5.5 mo. instead of one month. A series of sugars with films of known composition was made in the laboratory by coating large crystals of sterilized sugar with sterilized blackstrap molasses and 60 Brix sugar syrup in definite proportions and purging in the centrifugal, a method previously employed with success. Blackstrap molasses, 5/6 blackstrap + 1/6 syrup, 4/6 blackstrap + 2/6 syrup, and 3/6 blackstrap + 3/6 syrup when arranged in order of increasing moisture ratio are designated as Concentrations A, B, C, and D, respectively. These sugars were inoculated with *Aspergillus*

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1 Department of Bacteriology, Louisiana Sugar Experiment Station, New Orleans, La.

2 Journal of Industrial and Engineering Chemistry, 12 (1920), 256.

niger, Aspergillus Sydowi Bainier and *Penicillium expansum,* at the rate of 100, 1000 and 10,000 spores per gram. At the end of 5.5 mos. incubation at room temperature the contents of each flask were analyzed for sucrose by direct polarization and modified Clerget, and for reducing sugars and moisture. It has already been shown[3] that the most satisfactory criterion of deterioration of sugar is the gain in per cent of reducing sugars. In order to summarize the results as briefly as possible, there is given in Table I the increase over check of the averages of closely agreeing triplicate determinations of reducing sugars. The abbreviation M. R. stands for moisture ratio, which value is derived as follows:

$M.\ R. = \dfrac{\text{Moisture}}{100 - \text{Polarization}}$; *Asp. n.* is the abbreviation for *Aspergillus niger,* while *Asp.* S. B. and *Pen.* represent *Aspergillus* Sydowi Bainier, and *Penicillium expansum.*

TABLE I—SUMMARY SHOWING THE INFLUENCE OF AMOUNT OF MOLD INOCULUM ON THE DETERIORATION OF SUGARS WITH FILMS OF KNOWN CONCENTRATION. INCREASE IN PER CENT REDUCING SUGARS OVER CHECK.

No. Spores per Gram.	Concentration.											
	A M. R. = 0.14.			B M. R. = 0.16.			C M. R. = 0.18.			D M. R. = 0.24.		
	Asp. n.	*Asp. S. B.*	*Pen.*	*Asp. n.*	*Asp. S. B.*	*Pen.*	*Asp. n.*	*Asp. S. B.*	*Pen.*	*Asp. n.*	*Asp. S. B.*	*Pen.*
100	...	...	...	...	0.09	0.01	...	0.09	0.07	...	0.10	0.10
1000	...	0.02	0.02	...	0.05	0.04	0.12	0.22	0.17	0.04	0.18	0.18
10,000	0.04	0.21	0.11	0.03	0.12	0.11	0.27	0.31	0.28	0.12	0.27	0.28

It will be seen from this table that in every instance but one an increase in the number of spores per gram caused an increase in per cent of reducing sugars over check. This held true not only at every concentration employed, varying in moisture ratio from 0.14 to 0.24, but likewise for every organism used at any single concentration. This fact is very significant and indicates conclusively that an increase in degree of inoculation of mold spores at any definite concentration is responsible for an increase in deterioration of sugar. This corroborates our previous work where solutions varying from 10 to 70 per cent were employed,[4] as well as the results obtained in the experiment just concluded,[5] where an inoculation of 100,000 spores per gram at each of the above-mentioned concentrations was employed. A closer scrutiny of the results presented in Table I reveals the fact that the increase over check of reducing sugars with an inocu-

[3] Louisiana Bulletin 166.
[4] J. Agr. Res. 18 (1920), 537.
[5] Journal of Industrial and Engineering Chemistry, Loc. cit.

lation of 100 spores per gram is insignificant at practically all concentrations. The same is true of an inoculation of 1000 spores in the two higher concentrations, namely, A and B. This is of practical importance in defining the limits at which deterioration occurs, since in plantation granulated sugars the moisture ratio may be said ordinarily to be below 0.18. It is generally considered that good Cuban raw sugar likewise should have its moisture ratio below 0.25 to 0.33. Thus, it might be inferred from the foregoing data that where the moisture ratio is below 0.18, mold infection of less than about 5,000 spores per gram would cause slight, if any, deterioration. As a rule we have rarely found sugars which had more than 250 mold spores per gram, although no quantitative survey has been carried out as exhaustively as might have been desirable.

When the two lower concentrations C and D are considered, we find that there is evidence of deteriorative activity with 100 spores per gram, while with more than 1000 spores the deterioration is quite appreciable. It would appear, therefore, that for safety (from the standpoint of mold infection) a sugar having a moisture ratio of 0.17 to 0.18 would have to contain less than 100 mold spores per gram. On the other hand, a mold infection of more than 10,000 spores per gram will cause a deterioration in sugars with moisture ratios varying from 0.14 to 0.24. It may be noted in this connection that in the previous investigation an inoculation of 100,000 spores per gram was responsible in one month for a deterioration in sugars with moisture ratios varying from 0.08 to 0.20.

An interesting fact which corroborates all our previous work with sugars, as well as solutions, is that at any definite concentration and with an equal number of spores per gram *Aspergillus* Sydowi Bainier is more effective than *Penicillium expansum*, which in turn is more effective than *Aspergillus niger* in deteriorative activity.

TABLE II—SUMMARY SHOWING THE INFLUENCE OF CONCENTRATION OF FILM ON DETERIORATION OF SUGARS BY MOLDS

Concentration	Moisture Ratio	Per Cent Gain in Reducing Sugars Over Check: 100 Spores per G. *Asp. n.*	100 Spores per G. *Asp. S. B.*	100 Spores per G. *Pen.*	1000 Spores per G. *Asp. n.*	1000 Spores per G. *Asp. S. B.*	1000 Spores per G. *Pen.*	10,000 Spores per G. *Asp. n.*	10,000 Spores per G. *Asp. S. B.*	10,000 Spores per G. *Pen.*
A	0.14	...	...	...	...	0.02	0.02	0.04	0.21	0.11
B	0.16	...	0.09	0,01	...	0.05	0.04	0.03	0.12	0.11
C	0.18	...	0.09	0.07	0.12	0.22	0.17	0.27	0.31	0.28
D	0.24	...	0.10	0.10	0.04	0.18	0.18	0.12	0.27	0.28

In Table II is presented a summary of results so arranged as to show the influence of concentration of film on the deterioration of sugars by molds It must be stated at the outset, however, that where the increasing increments of moisture are so slight as in the present instance, and especially when dealing

with the activity of microorganisms over such a long incubation period, it is hardly to be expected that the differences will be very sharply defined. However, it will be observed that as a rule an increase in moisture ratio (which actually signifies a decrease in concentration) is responsible for an increase in deterioration with any single inoculation. It is not necessary to repeat here what was stated in the discussion of Table I concerning the limiting effects of concentration with any definite inoculum. Suffice it to say that this work fits in very closely with our preceding investigations and proves quite conclusively that with a high mold infection, deterioration takes place in sugars with moisture ratios below 0.14, or, according to the previous experiment, at 0.08. This substantiates the claim previously made that "the factor of safety for sugars well infected with fungi would appear to be lower than is generally supposed," and defines more clearly what such limits must be. In other words, knowing the number of molds present in any sugar, it may be predicted (from the standpoint of mold infection alone) what deterioration may be expected in a storage period of about 5 months with a sugar of known moisture ratio. It is to be assumed that at the present time we have carried through to completion, from a survey of mold speciess in sugar sugars are not stored for such a long period of time, but the differences obtained upon a long incubation period are not so much greater as to invalidate the above generalizations, as will be seen from Table III, which gives a comparison in the reducing sugar content of inoculated sugars with films of Concentration D (moisture ratio = 0.24) after 1 and 5.5 months, respectively. It will be readily seen that the differences in incubation as represented by the gain in per cent of reducing sugars are indeed slight when compared with the initial gain over check in one month.

TABLE III—COMPARISON IN CONTENT OF REDUCING SUGARS OF INOCULATED SUGARS (WITH FILMS OF CONCENTRATION D) AFTER 1 AND 5.5 MONS. INCUBATION, RESPECTIVELY.

Incubation	Check	*Asp. n.*	Gain over Check	*Asp.* S. B.	Gain over Check	*Pen.*	Gain over Check
After 1 month	0.23	0.44	0.21	1.10	0.87	0.77	0.54
After 5.5 months	0.23	0.53	0.30	1.46	1.23	0.87	0.64
Gain in reducing sugars, per cent	0.00	0.09	...	0.36	...	0.10	...

Next to the elimination of deterioration, the most important commercial consideration is prediction of the keeping quality of a sugar. Table IV is a tentative plan based on the results obtained in all our investigations which will give some conception of the deterioration to be expected from a definite number of molds in sugars of known moisture ratio. It must be clearly understood that this plan is advanced with considerable diffidence, and that its value rests on further verification. Furthermore, it is of importance to note that in the above table mold infection only has been considered. We have data which are concerned with deterioration due to bacterial infection and unquestionably the bac-

terial flora would seriously influence the deterioration of sugars as shown in the important researches of previous investigators. However, since individual molds, such as *Aspergillus* Sydowi Bainier, *Penicillium expansum,* and *Aspergillus niger,* are vastly more efficient in their deteriorative activity than any bacteria that have come to our attention, and since the first-named mold is to be found in practically all sugars, it may be that the above table will prove of some value to those who are ready to take cognizance of the molds which are undoubtedly causing large economic losses in the sugar industry. In Table IV it will be seen that the facts previously discussed have been so arranged that one may tell at a glance what deterioration, if any, might be expected. It was not deemed necessary to carry out the work in moisture ratios beyond 0.24, because it is generally conceded that sugars having a moisture ratio above 0.30 are susceptible to deterioration. Browne,[6] Owen,[7] and others have advanced much valuable evidence on this point.

TABLE IV—DETERIORATION TO BE EXPECTED FROM A DEFINITE NUMBER OF MOLDS IN SUGARS OF KNOWN MOISTURE RATIO.

	Moisture Ratio = $\frac{\text{Moisture}}{100 - \text{Polarization}}$						
Number of mold spores per g.	0.08	0.14	0.16	0.18	0.20	0.24	Over 0.24
0–100	—	—	±	+	+	+	+
100–1,000	—	±	±	+	+	+	+
1,000–10,000	±	+	+	+	+	+	+
10,000–100,000	+	+	+	+	+	+	+

\+ Deterioration.
— No deterioration.
± Slight, if any, deterioration.

This paper may be said to round out one phase of the problem of sugar deterioration, namely, that concerned with the importance of mold infection, which we have carried through to completion, from a survey of mold spores in sugar and their deteriorative activities in sugars and solutions to a study of the effect of varying the amount of inoculum and concentration on deterioration.

The writer wishes to thank Messrs. D. F. Stanfill, Jr., and R. S. Hays for their help with the chemical analyses and the Station staff for their assistance, and is indebted to Mr. W. L. Owen for his kindness in reading the manuscript.

Summary.

1—An increase in number of mold spores inoculated into sugars (with films of varying concentration) is responsible for an increase in deterioration.

2—A decrease in concentration of the films surrounding the sugar crystals is responsible for an increase in deterioration.

3—A table is presented showing the deterioration which may be expected from a definite number of molds in sugars of known moisture ratio.

[6] Journal of Industrial and Engineering Chemistry, 10 (1918), 178.
[7] Louisiana Bulletin 162.

4—At moisture ratios of less than 0.18 there is little, if any, deterioration with a mold infection of less than 5,000 spores per gram. More than this number of spores induces deterioration. At moisture ratios above 0.18, deterioration occurs with upwards of 100 spores per gram.

5—At any definite concentration and with an equal number of spores per gram *Aspergillus* Sydowi Bainier is more effective than *Penicillium expansum* or *Aspergillus niger* in its deteriorative activity. [W. R. M.]

On the Burning of Fuel Oil.*

By H. J. Vandereb.

The shortage of coal and abnormal rise in coal prices of the last few years has given rise to a lively interest in the use of fuel oil under power boilers. Quite naturally, comparison as regards cost of coal and oil is the principal factor in this. For certain localities such a comparison is at present favorable to the use of oil. Especially is this true for New England and other points on the Atlantic Coast, remote from the coal fields. Add to this the uncertain delivery of coal of the present time from causes we need not here mention, and you have a fair index to the oil fuel situation.

As to how long these price relations can possibly continue, it is practically impossible to make a reasonably safe guess. From the present knowledge of the available world supplies of oil and coal, which necessarily is rather vague, it seems, however, to be generally taken as a foregone conclusion that the oil supply will have ceased many centuries before coal will show signs of exhaustion. Undoubtedly at some future day, which may be in the lifetime of the present generation, the operation of the inexorable law of supply and demand may give back to coal the nearly undisputed monopoly it so long has enjoyed in the field of steam power generation. So long as the price remains favorable, however, oil will be a big factor in power plant operation and the present indications are that this may be for a number of years to come.

It is the purpose of this article to give a few helpful hints, gathered from the best information available, to steam users who desire to look into the desirability of changing from coal to oil for their boiler plants. In every case it is desirable that a reliable estimate be made in advance, of all the cost involved in making the necessary changes in the equipment. While the cost of the actual oil burning apparatus is light as compared with, for instance, mechanical stokers, there may be costly changes necessary in the boiler settings in order to obtain a reasonably high efficiency, which may drive the cost up to a disappointing figure. In addition to this, account should be taken of the possible necessity of installing

*Reprint from "The Locomotive" of the Hartford Steam Boiler Inspection and Insurance Company, January, 1920.

extensive storage tank capacity, depending on the proximity of the plant under consideration to an oil distributing center. For plants that are a considerable distance away from such an oil depot it is suggested to have a storage capacity of from thirty to forty days' supply to take care of any interruptions of the regular delivery of the oil. Steam plants that have the good fortune of being located right near an oil depot can of course avoid a heavy investment in storage tanks, and for such plants a week's supply on hand might be considered sufficient. But even for such installations, especially if they be public service plants with contracts for their power output, business foresight may suggest the desirability of the right proportion of reserve supply to insure continuous service under unusual circumstances. With a further view to the possible serious interruption of the oil supply at the source it has been suggested that no oil burning installation should be undertaken that would not permit changing back to the use of coal in a reasonably short time. In making estimates on proposed oil installations and comparing the cost of the oil itself with that of coal, use can be made of a handy approximate rule, sufficiently accurate for practical purposes, which is the simple relationship between the cost of the two fuels as pointed out by Mr. W. M. McFarland. This is, that for equal steam production the fuel cost will be the same when the number of dollars of the price of coal per ton (of 2,240 lbs.) is double the number of cents of the price of oil per United States gallon. This rule is based on the respective average heat values of oil and coal per lbs. and takes into account the better efficiency obtainable with oil than is possible with coal. Any other possible economies incident to the use of oil, such as the lower labor cost of handling fuel oil as compared with that of coal and ashes, are not included in this rule.

The fuel oil that is at present sold for power purposes is, with very little exception, the heavy residuum that remains after taking off by partial distillation from the crude oil the valuable lighter hydro-carbons, naphtha, gasoline and kerosene. This so-called "topping" of the crude oil enhances the value of it as fuel rather than diminishing it, as the flashpoint is thereby raised to a point where the fuel can be handled with greater safety, especially after being heated to the temperature necessary for properly atomizing it at the burners. The calorific value of the "topped" oil is not any less than that of the crude oil, in fact it is even a little higher.

The Advantages of Oil Over Coal.

From a number of viewpoints oil is an attractive fuel for steam generation. As already indicated in the foregoing it is possible to obtain a higher efficiency with oil than with coal. It is comparatively easier, so far as physical effort is concerned at least, to obtain almost perfect combustion with oil burning and keep out of the furnace unnecessary excess air from the fact that there are no furnace doors opened every few minutes as with the hand firing of coal and there is no cleaning of fires with its attendant serious cooling off of the furnace. The required intensity of the heat from the burners is under practically instantaneous control to meet changes in the load. There is furthermore possible a con-

siderable saving of labor in an oil burning plant as compared with that required for the handling of coal and ashes and there is a complete absence of dust.

For the small plant of one or two boilers a saving in the labor item should not be expected, since of course for such an installation the same number of men will be required to tend to the burners as would be to shovel coal in the furnace. There are, however, many small plants where it could be expected of one man, with more justification from a safety standpoint, to tend to both the engine and boiler, if oil were used, than where he has considerable coal shoveling to do. But for the larger plant the labor economy is a real factor. One man can tend a considerable number of oil fired boilers with almost the same facility as he can one boiler. One other feature that may be mentioned in favor of oil fuel as compared with coal, is that the troubles of spontaneous combustion, so common with coal of high sulphur content, are entirely excluded with oil fuel.

There are almost no real disadvantages connected with oil burning to offset the several advantages mentioned. The one serious obstacle that can be mentioned is that in congested city districts the use of oil may be made prohibitive by local ordinances requiring special conditions with regard to location and isolation of storage tanks with a view to safety in case of fire. Some of this trouble, however, may be overcome by piping the oil underground to the plant from a point where oil can be conveniently stored with better safety.

The oil as received may contain a certain percentage of moisture, which must be eliminated by giving it time to settle to the bottom of the storage tanks. It is therefore desirable to have always more than one tank for any conditions of required storage capacity so that the oil as it is used may always be pumped from a tank in which the settling of the moisture is as complete as practicable. Each tank should be provided with a bottom drain cock at its lowest point to run off any collected water or dirty oil.

At the ordinary outdoor temperatures, especially in the northern latitudes, it is necessary to heat the oil in the storage tanks to reduce its viscosity to a point where it can be pumped. As it is too wasteful to attempt to heat the whole tank to the desired temperature it is entirely possible to accomplish this by placing a steam coil right near the point where the suction pipe enters the tank. On all piping used for the transmission of oil it is desirable to have a steam connection so that they may be blown through and cleared of any accumulations of silt which is more or less present in all fuel oil. It is absolutely essential to have some effective form of strainer placed in the suction pipe leading to the pump in order to catch the fine grit and so to prevent undue wear of the pump cylinders. In order to eliminate the pulsations of the pump, so that a steady flow may be had at the burners, the pumps should be provided with an ample air chamber.

Heating of the oil is furthermore a necessity to aid in the proper atomization at the burner. It is most convenient and economical with the heavy oils now being used to do the heating of the oil in two steps, namely, to raise the temperature of the oil near the suction outlet of the storage tank sufficiently to reduce its viscosity to a point where it can be pumped and to have in the fire-

room a separate heater in which the oil can be given the desired temperature for proper atomization. The final temperature of the oil just before atomization is usually about 140° to 160° Fahrenheit, where the oil is atomized by means of steam, but it is best to find by trial the most suitable temperature for each particular oil used to effect the best economy. Great care should be exercised to not heat the oil above its flashpoint. The flashpoint of an oil is the temperature at which inflammable vapor begins to be liberated at its surface. Thermometers should be present on the suction pipe leading from the storage tank to the pump and on the pressure pipe between the pump and the burners so that at all times proper control of the temperature may be had. The inflammable vapors referred to are a distinct danger and may give rise to disastrous explosions in the combustion space of the boilers, when, for instance, the oil valve to a burner is inadvertently left partly open under an idle boiler. Such gas explosions are known to have done great damage to the setting walls and serious personal injury. Aside from this danger the proper operation of the burners is affected by the presence of vapor in the pipes as the oil will under such conditions flow irregularly, causing sputtering of the flame.

Some Details of the Burners.

The function of an oil burner is to scatter the oil in a spray of minute particles to make it possible for the oxygen of the air to come in contact with as much surface of the fuel as it is feasible to expose it. A solid stream of oil has a small surface as compared with the aggregate surface of all the minute oil drops that result when the solid stream is broken up into a fine spray. The work performed by the atomizing agent is simply the work of stretching the surface of the oil, hence the finer the spray the better are the chances for perfect combustion. The only limitation on the fineness of spray is the cost involved in producing it.

The burners that are most commonly used can be classified under two general types: 1st, spray burners, in which the oil is atomized by means of a jet of steam or air, and, 2d, mechanical burners, in which the oil is forced under considerable pressure through a small aperture of particular shape causing it to break up into small particles. As the small aperture of the mechanical burner will wear quickly larger by any grit in the oil, thus rendering it useless, the thorough straining of the oil is especially important when mechanical burners are used. It is, however, well for any type of burners to have a strainer in the pipe between the pump and the burners to catch any gritty or solid substance that may pass the strainer in the pump-suction line.

Mechanical burners have an advantage over those that atomize the oil by means of an air jet because of the necessity of an air compressor with the latter type. They also have, theoretically at least, an advantage over steam spray burners because of the fact that all steam that is introduced into a furnace leaves the furnace (when combustion is complete) as steam, which carries with it some of the heat generated from the fuel, entailing a certain amount of loss. It is sometimes asserted that the burning of the hydrogen that is set free when the steam is decomposed by the high furnace temperature into hydrogen and

oxygen, will add a certain amount of heating value to that of the fuel. The fallacy of this will be obvious when one considers that it takes just as much heat to decompose the steam into its component elements, hydrogen and oxygen, as can possibly be realized when these elements are again united by combustion.

Another advantage of mechanical burners over steam spray burners is that they are generally better adapted to take care of wider variations of load, which necessarily is conducive to better economy under certain conditions of operation. However, the extreme simplicity of the steam atomizing burner and the excellent economy obtained with it when constructed on correct principles, together with the comparatively low oil pressure and temperature it requires, has made this type the favorite for stationary work. Burners using air as an atomizing agent are in successful operation, but steam atomizing burners are used more generally. Wherever the loss of fresh water is not a vital factor the latter are usually the most satisfactory. The steam consumption has been found for the better make of burners to be approximately 2% of the total steam generated.

From a safety standpoint a so-called flat-flame burner is preferable over a burner producing a cone shaped flame for most types of boilers, as it is simpler with the former to avoid the impinging of the flame on portions of the heating surfaces of the boiler. Localization of the intense heat of the flame on tubes or shell of a boiler will invariably result in overheating and blistering of the metal and should be carefully guarded against. Space forbids a detailed description here of the different types of burners on the market. Such of our readers as are interested in further perusal of this detail are referred to "The Science of Burning Fuel Oil," by W. N. Best, and "Oil Fuel," by E. H. Peabody.

Ample Combustion Space an Absolute Requirement.

The selection of the right type of burner, while of course important, is of less significance in obtaining the proper boiler efficiency than is the proper furnace volume and general design of the furnace. The ideal conditions of an oil furnace are that the particles of burning oil have an opportunity to linger just long enough in the furnace to be completely consumed before coming in touch with the relatively cool boiler surfaces, which would extinguish them, with the possibility that they are re-ignited higher up in the setting or in the uptake with a resultant waste of heat.

Ample space must therefore be provided in the primary combustion chamber; more indeed than for almost any other fuel. This extremely important fact may make the change from the use of coal to oil prohibitive for boilers that are set low.

It has proved feasible with existing coal burning boilers, in which the distance above the grate is not less than about 40 inches, to form a chamber for the oil flames by placing a layer of firebrick over the gratebars, leaving a sufficient number of openings in this layer of brick for air admission. It is safe to say, however, that it is best in any case, both from a safety and an economy standpoint, to remove the gratebars and install a flat checkerwork of firebrick to take the place of the grate, but placed close to the ashpit floor, leaving only sufficient space under the checkerwork to form an air duct.

The bridgewall should then be cut down to about the top of this checkerwork. In view of the high temperature to which the brickwork in an oil furnace is subject, which may reach 2800° to over 3000° Fahrenheit, only the best quality of firebrick should be used. It is impossible to give any sort of a definite rule for the proper amount of required combustion space. This can best be determined for each individual installation and its surrounding conditions by someone having extended experience with oil burning.

For water tube boilers of the inclined tube type the so-called "rearshot" burner should be used. This name applies to location of the burner rather than to type. It simply means that the burner is placed just in front of the bridgewall and shoots the flame toward the front of the boiler. The objects gained by this are that the flame projects in the direction in which the furnace increases in volume, due to the fact that the tubes are inclined toward the front, and the possibility of the flames impinging on the tube surfaces is practically excluded.

Fuel oil is successfully being used under vertical firetube boilers of the Manning type, but it is found that there is a tendency that not all the tubes participate in transmitting the products of combustion. The tubes directly over the burner proper are apparently idle, while the tubes in the rear or the direction of the flame transmit all the heat. In such a case, good use may be made of retarders, consisting of spirally twisted strips of sheet metal, placed in the rear tubes which will have the effect of distributing the hot gases more uniformly.

Fuel Economy Hinges Largely on Damper Adjustment.

The proper amount of draft through an oil burning furnace is a matter of great importance and on it hinges largely the success or failure of the installation in competition with coal. Less draft is required for successful burning of oil than in the case of a coal furnace of the same relative capacity. The reasons for this are that with oil burning the draft does not have to overcome the same retarding influence as is produced by a fuel bed, and the action of the oil burner itself is moreover to some extent that of a forced draft. The volume of gases for a given rating is smaller with oil burning than with coal. From this it follows that it is not necessary to have as large a stack area for oil burning boilers, nor does the stack have to be as high as for coal burning of the same capacity. The proper amount of draft to be allowed when changing over an installation from coal to oil burning can be taken care of by keeping the stack damper partly closed, but it is better, and it makes the installation more fool-proof, to contract the area of the gas passage of a stack of too large capacity by means of a fixed plate with an opening in the center of the required size.

On the other hand there must be a sufficient draft suction to steadily carry off the products of combustion at a certain maximum rate which can only be determined by test for the best obtainable economy of fuel. If an insufficient amount of draft is allowed at the stack so that the action of the burner as a draft producer is relied on to push the gases, the action of the heat on the brickwork of setting walls and baffles will cause them to rapidly deteriorate. It is, therefore, a case of striking a happy medium between the evil of too much draft causing waste of fuel and that of not enough draft involving high upkeep cost.

As stated before the question of allowing just the right amount of draft is very important for proper economy and because of the fact that resistance to the draft is considerably less through an oil burning boiler than through a coal fired boiler, the handling of the damper is a much more sensitive operation with oil than it is with coal. It is, therefore, almost needless to state that a suitable draft gauge, located so that it can be conveniently read, is practically indispensable when economy is desired. Carelessness in manipulating the draft will invariably lead to gross waste of fuel.

In one installation, that recently came to our notice, the records of oil consumption showed a "mysterious" gradual increase, until finally it was nearly double what it had been at first, although the steam output from the boilers was practically unchanged. The reason for this marked increase in the oil consumption was not far to seek. The emphatic and careful instructions, given at the time the oil equipment was installed, had "wore off" and the firemen had come to regard the close regulation of the draft as a useless bother. Consequently they were running with the stack damper and ashpit doors wide open, causing a short white flame, which they no doubt regarded as hotter and therefore more efficient. The result was, as stated, a doubling up of the oil consumption. Here was a case where, with practically no effort, about ten barrels of oil per day could have been saved over a considerable period.

A clear stack on an oil burning installation is usually an indication that too much draft is passing through the furnace with a resultant low efficiency, since all the unnecessary excess of air simply acts as a cooling agent and carries heat up the stack that ought to have served in making steam.

A slight haze coming from the stack indicates that conditions are more nearly ideal. In order to establish the best furnace conditions for any given load, the most satisfactory method is, of course, by means of flue gas analysis, but in the absence of the proper apparatus for this, use can be made of a reasonably reliable and simple rule. When the furnace is well alight and the walls uniformly heated up to a high temperature, the draft should be pinched down by gradually closing the stack damper to a point where the flames have a slightly smoky fringe, when the damper should be opened again just sufficiently to clear the flames. [W. E. S.]

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Report of Entomological Work in Australia, 1919-1920.

By Frederick Muir.

Leafhopper.

I returned to Honolulu on June 21st, after an absence of thirteen months. When I left last year I considered that three to four months would be ample time to accomplish the object of my journey, viz.: to procure a large colony of *Drypta*.

In my letters from Australia at various times I have mentioned the difficulties that have beset me in my work during the last thirteen months, but I would like to recall them here, as it is necessary for the correct understanding of the time occupied in the work and the results arrived at. In a normal season, without abnormal hindrances, four months should have been ample time to proceed to Australia, collect a good colony of *Drypta* and return. As it was, thirteen months have been spent and the original intention has not been achieved.

Upon my arrival at Auckland in May of last year I first encountered difficulties, as the shipping strike in Australia held the S.S. Niagara in New Zealand for two weeks. This delay was fatal to the *Scolia manilae* I was taking to Queensland, as the cold at Auckland killed them all off. But the Queensland authorities appreciated the effort we made and did all they could to assist me during my stay.

Upon arriving in Sydney I found all the coastal shipping tied up on account of strikes. Had it not been for this I should have immediately joined Dr. Williams and he would have succeeded in getting a large colony of *Drypta* away.

Expecting the strike to be settled each day, I did not proceed overland, as the journey is one to be avoided if possible. I therefore decided to work the southern sugar cane areas, where Messrs. Perkins and Koebele found so favorable conditions in 1904–05.

The 1918–19 season had been exceedingly dry and I found the Bundaberg district, where Perkins and Koebele did most of their work, in an exceedingly bad condition. The sugar crop of the district was only one-third the average and some of the mills in the district did not crush at all; vegetation of all sorts was affected and the grass mostly dried up. Insect life was at a low ebb and one could not believe that it was the same district that Messrs. Perkins and Koebele had collected so much material in.

When the shipping strike was settled I got up north and found the condition very similar. Rains had failed and even in such places as Innesfall, the wettest place in Australia, they were carting their drinking water from some distance. Insect life of all descriptions was scarce and *Drypta* exceedingly so. There was therefore nothing to do but wait for the rains to commence in December and January. In the Macknade district they had one good rain at the end of January, but after that the drought set in again, and it did not break until April 20th. From then until I left, on May 10th, we had only one day in which the sun shone for more than two hours; between April 20th and 25th twenty-five inches of rain fell and up to the 10th of May thirty-seven inches fell. The river was in flood sixteen feet above the bridge, and the creeks were all overflowing and most of the fields with a foot of water. It was only owing to the assistance of the Colonial Sugar Refining Company that I managed to get out of the district to the rail head and get a train for Townsville.

A second shipping strike had hindered my movements, compelling me to go west some three hundred miles and take a motor trip 120 miles from rail head to rail head. The heat out west was excessive, being 120° at Winton the day I arrived, and 110° at Longreach. The drought has played fearful havoc with the western part of Queensland and New South Wales; hundreds of thousands of sheep have died. Along forty miles of road, from one sheep station to the rail, there were sixty dead horses. The dead sheep were not counted.

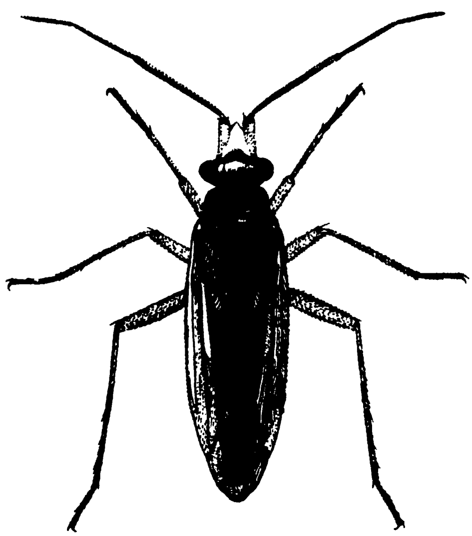
Under such abnormal conditions insect life was exceedingly scarce. In fields where Dr. Williams could collect 100 to 150 Dryptas per day, I could not get fifty in three months. If, after the heavy rains from the 20th to the 25th of April, it had cleared up and been sunny and warm, I believe Dryptas would have appeared in numbers enough to have enabled me to have collected a decent colony, but the continued bad weather and the flooded conditions of the country made this impossible.

The trip altogether was the most unsatisfactory one I have undertaken and I did not accomplish what I set out to do, namely, to get a colony of *Drypta*.

But although I did not do what I had set out to do, yet the time was not wasted as I was enabled to study *Perkinsiella* under various conditions and draw certain definite conclusions that led to the discovery of an insect that I hope will be of greater value than the *Drypta* and will eventually enable us to cope with our leafhopper problem successfully. This insect is a small Heteropterous bug named *Cyrtorhinus mundulus*.

In North Queensland the sugar cane districts are normally wet, especially from January to May, when cyclones often strike the coast and cyclonic storms are common. My last three weeks at Halifax demonstrated what can happen in this line. In spite of this fact *Perkinsiella* is fully controlled.

For several years I have held that the *chief* cause of our leafhopper outbreaks is climatic conditions, such as heavy rains. Mr. Pemberton, after a study of the subject, has come to the same conclusion. These rains are too severe for the minute egg parasites we depend upon for the control of the leafhopper and so they are wiped out and the leafhopper gets ahead. The conditions I found prevailing in North Queensland were such that either my conclusion as to the cause of our outbreaks was wrong or else there were other factors than the egg-parasites in North Queensland that were responsible for the control of the leafhopper. *Drypta* was so scarce that I had to rule it out of the factors acting during 1919-1920, whatever it may do in normal times.



Cyrtorhinus mundulus (Breddin).

The small number of young in the field in comparison to the number of adults made me suspect that either something was impairing the fertility of the hoppers or destroying the eggs. Upon dissecting adult females I discovered the presence of a yeast-like fungus which was numerous in the body fluids. This fungus passed through the walls of the ovarian tubes and entered the eggs, where they were always found congregated in a round mass at the posterior end of the egg. Upon examining eggs laid in the cane leaves I found that 80% were destroyed, having collapsed and, in most cases, a fungus growing from them. An examination of the eggshell under a moderate power microscope showed no break or damage, and I therefore suspected that the destruction of the eggs was due to the fungus. I had no facility for the proper cultivation of this fungus, but the spores from the fructification of the fungus growing from the eggs developed into yeast-like cells similar to those found in the body fluids and eggs. The yeast-like cells from the body fluid and the eggs grow out into hyphae under certain conditions.

Some of my observations led me to think that the fungus was not the cause of the destruction of the eggs, and that the fungus only developed when some other factor had killed the eggs or embryos. This idea was further strengthened when I heard, in response to a question, that the same, or a similar, fungus existed in *Perkinsiella* in the Hawaiian Islands.

It therefore became necessary to find some other cause to account for the death of 80% of the eggs and, after a great deal of field observation, this I found was due to a small Heteropterous bug named *Cyrtorhinus mundulus*. This insect belongs to the same order as the *Perkinsiella* and has similar mouth parts. But, as far as I could find out, it never sucked sugar cane, but lived entirely on the eggs of leafhoppers, which it pierces with its very slender "beak" and sucks out the contents, leaving the eggshell unbroken, the puncture being so minute that it is unrecognized.

The eggs of *Cyrtorhinus* are laid in small crevices in the cane leaf, often in the egg slit of the Perkinsiella. The eggs are parasitized by a mymarid parasite very similar to *Paranagrus* on *Perkinsiella*, but specifically distinct. The young bug is bright scarlet and very active, hiding at the base of the cane leaf. When it comes upon a batch of *Perkinsiella* eggs it feels it all over with the tip of its proboscis (labium) and then inserts its hair-like mouth organs and feeds. The adult is very active and not easily seen as one goes through a cane field, as the movement of the cane leaves two or three yards away cause it to fly off. But by sitting down for half an hour or more in a good situation one can get an estimate of the numbers about and see that they can easily be responsible for the 80% of the eggs destroyed.

I consider that this insect is the chief cause in keeping *Perkinsiella* in check in North Queensland. It is unaffected by storms, as after three weeks of rain and floods the young and adults were as abundant and active as ever. The egg parasite *Paranagrus* is present, but in very small numbers, both at the end of a long dry spell and after the heavy rains, and can play but a minor role in the checking of *Perkinsiella*. *Drypta* was so scarce that it could have played but a small part during the time I was working in the district. Other predators were equally scarce during the same time. I regret not being able to bring back a colony of *Drypta*, as I would like to see it established in our Islands, but I believe *Cyrtorhinus* will be more valuable when once established. Among my collection from Fiji made in 1905–1906 are specimens of this insect; also a closely allied species. By my notes I see that I experimented with it on young hoppers but got negative results. As I was only seeking enemies of the young and adults then, I did not try it out with eggs and so failed to discover its importance.

The question has been raised as to the possibility of *Cyrtorhinus* destroying our *Paranagrus* and so doing more harm than good. To this there are two answers:

(1) If it were to entirely supplant it and was equally effective in destroying the eggs of *Perkinsiella* it would be a gain, as its ability to stand up against the heavy rains in certain districts would prevent some of our worst outbreaks.

(2) There is no reason to believe that it will supplant the *Paranagrus*, as it has not done so in Australia or Fiji. It will attack both parasitized and unparasitized eggs and the joint results will be a distinct benefit. For example,—if they both attack 80% of the eggs then the results of *Paranagrus* alone would be for twenty hoppers and eighty parasites to hatch out of every 100 hopper eggs. If *Cyrtorhinus* was also acting along with *Paranagrus* then the ultimate result would be four hoppers and sixteen *Paranagrus*, the same proportion but a vastly improved condition.

Having failed to get a booking on one of the Oceanic boats, which only take two weeks from Sydney to Honolulu, I could only procure a passage on the S.S. Makura, advertised to sail from Sydney on April 27th. As it took me a week to get from Halifax to Sydney and I had to be in time to arrange passports, etc., I had to start early in the month. Upon arrival in Sydney I found that the date of departure had been postponed till the 3rd of June. This delay, along with the three weeks en route from Sydney, made me despair of getting

anything over alive, but upon examining the cages we found there were twenty-three young and three adults. Since then several of the former have become adults.

We therefore have good reasons to hope that we shall be able to start a colony and eventually increase it so as to be able to turn out fair numbers into the field. This will be a fairly slow process, as they do not increase at a great rate and the supply of food for great numbers will not be easy to maintain.

The question therefore arises if, to avoid considerable delay, it would not be advisable to get a large colony from Fiji, a distance of only eight days.

Now that we know the habits and the best way to handle the insects in cages, this should be a simple matter (barring such hindrances as I encountered in Australia) and should not occupy more than ten to twelve weeks. There is also a second species in Fiji which we could get. The present would be the right time of the year to get it. I would ask to go myself, but my thirteen months wandering in Australia has made me weary of travel for a time. I would therefore suggest that, if it be decided to send for a large colony, either Dr. Williams or Mr. Pemberton should go. It might be useful for the latter to see leafhopper conditions in Fiji, as it would enable him to compare with Hawaiian conditions.

I strongly recommend that some one be sent to Fiji for these insects, as the time saved in establishing them in our Islands fully justifies the outlay. Should anything go wrong with our small colony in captivity, a not impossible contingency, we should then have to proceed to Fiji for a new one.

For the time being I would suggest dropping the *Drypta* until we have established *Cyrtorhinus* and watched its effect upon our leafhopper problem.

Wireworm.

The cable reporting the destruction caused by wireworms reached me after I had left Macknade on my way to Sydney. I could, therefore, not look into the problem myself, even if the entomological conditions caused by the unusual drought had not made such work for this season almost impossible. In conversation with planters and with the Government Entomologists in Brisbane I learnt that in some of the forest land in North Queensland wireworms do considerable damage. It is possible that "white grubs" are the original attraction for this beetle and when they have hatched out or been devoured they then turn their attention to sugar cane. In Fiji wireworms are the worst pest after "borers."

Work on this beetle would take some considerable time on account of the length of the life cycle and the difficulty of getting material to work on. As one of the solitary wasps is the most likely parasite I think the spring would be the best time to work in Australia, providing that the season was favorable.

Antonina on Nut Grass.

Inquiries as to the damage done to nut grass by *Antonina* received very conflicting replies. Nut grass is abundant all through Queensland, especially

in cultivated land. The greater proportion are seedlings and it is through the seeds that cleared fields become restocked. One field at Macknade was of interest as the nut grass was very abundant and when I examined it, in October and November, *Antonina* was present but scarce, and "nuts" not numerous. In April and May the *Antonina* had increased enormously and "nuts" were abundant and covered with the insects. The plant had not flowered, but it was dead and dying all over the field, evidently entirely due to the presence of the insect. *Antonina* was found on two or three species of grasses[1] but did not appear to kill them. Sugar cane was growing in the field in question, a first ratoon, but I could find no specimens of *Antonina* attacking the roots.

I brought back a few specimens and after consulting with the Entomologist of the Board of Agriculture I am trying it out in our quarantine room. If necessary we can procure more from Australia through the post.

THE FERN-WEEVIL (SYAGRIUS FULVITARSIS PASC.).

When in the right districts I searched for this beetle without success. Inquiries of Coleopterists indicate that it is scarce under natural conditions, but abundant in greenhouses at times. No one knew anything of its habits or of any parasite attacking it. One would have to devote one's whole attention to it to do much good.

ACKNOWLEDGMENTS.

The Government Entomologist, Mr. H. Tryon, and his assistant, Mr. H. Jarvis, both aided me in every way they could. The Australian Sugar Planters' Association, through their Secretary, Mr. Pritchard, assisted me and gave me introductions to members of their Association wherever I went. But the greatest assistance I received from the Colonial Sugar Refining Company.

The Diffusion of Shredded Cane.

In a communication in the June, 1920, number of The International Sugar Journal, Alfred J. Watts of Pernambuco, Brazil, says in regard to the diffusion in cane "Mr. A. Fries in an article in your February issue quotes Mr. J. N. S. Williams as saying, 'If shredded cane be used for diffusion, this may solve the problem of preparing the material.' I do not know what cutters were used in Hawaii; apparently they were not very satisfactory, but if a 'Fives-Lille' cutter with properly ground knives, changed twice a day only, had been used I do not think he would be worried on that point.

[1] Preserved specimens brought back have been submitted to Mr. E. Ehrhorn, who states that the species found upon grasses is specifically distinct from that found upon "nut grass."

"As every diffusion worker knows, a clear cut slice of beet, or cane, with the minimum of broken pieces and crumbs, which will pack evenly leaving no channels, is the essential factor for good exhaustion without undue dilution, and that the Fives-Lille cutter, with hollow ground blades of the plane iron type and with well-filled hoppers allowing no dancing of the canes, will give. An exhaustion to 0.1 in the exhausted slices is easily obtained in a 16-cell battery and would only be advisable with a pure juice.

"As to the suitability of diffusion chips for fuel, after passing through a 6-roller mill with a moderate pressure and being fed with a screw feeder on the half-cone grate of a 'Godillot' furnace, in my experience they burn perfectly without any auxiliary fuel in the same furnace, except after cleaning. I do not know how much extra fuel has been needed elsewhere, but when I worked the plant in question 20 years ago, slicing over 300 tons per 24 hours and providing fuel for a workshop and locomotives, and steam for a large distillery with rectifier, the daily consumption of poor quality wood-fuel was reduced to nearly 10%. Pressing the work up to 350 tons of course still further reduced the percentage.

"It is so much a question of due attention to economy of heat produced in the first installation of a plant, by covering all hot surfaces, including juice and syrup tanks, saving of all hot water produced including all that from the several cells of the evaporator and much of that from the cooling waters of factory and distillery, and economy in using the steam produced, correct arrangement of flues and furnaces—in all of which details but the last we were very behindhand—that it is difficult to compare one factory with another, especially at a distance; but compared with the majority of factories in the district the diffusion factory had no cause to envy others in the matter of auxiliary fuel, at that time.

"Freedom from serious breakdowns is one great advantage of diffusion, a piece of iron in a bundle of canes being the worst thing to fear; but with a 10 minutes stoppage to replace knives and sufficient spare knives on hand it can be remedied. The chip mills are not pressed sufficiently to render breakdowns likely.

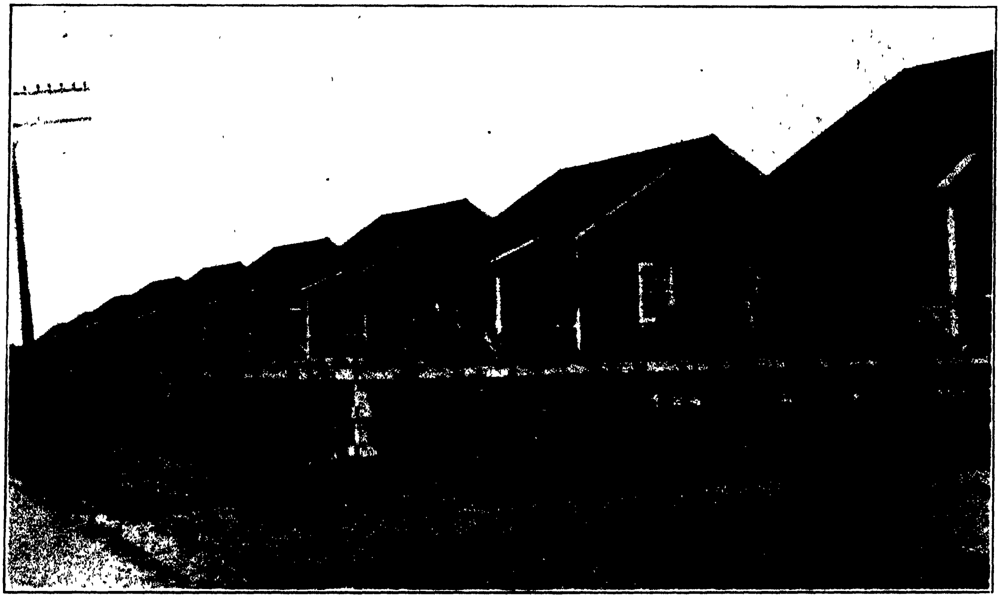
"The amount of 10 tons of firewood to 100 tons of canes worked may seem very high to some of your readers, but there are many deductions and allowances to be made for difficulties that should not be met with in a well-equipped modern factory and under other conditions. The fuel was of poor quality and much had lain for months in wet lowland; the supplies for the distillery, the locomotives and fuel for all the personnel on the place are included. Boiling was all done with direct steam in the pans and three jets of sugar, the first being fine white, were made.

"Taking all things into consideration I do not think that diffusion ever had a really fair trial, and I take it that the scattered nature of the various attempts had something to do with this contretemps."

[R. S. N.]

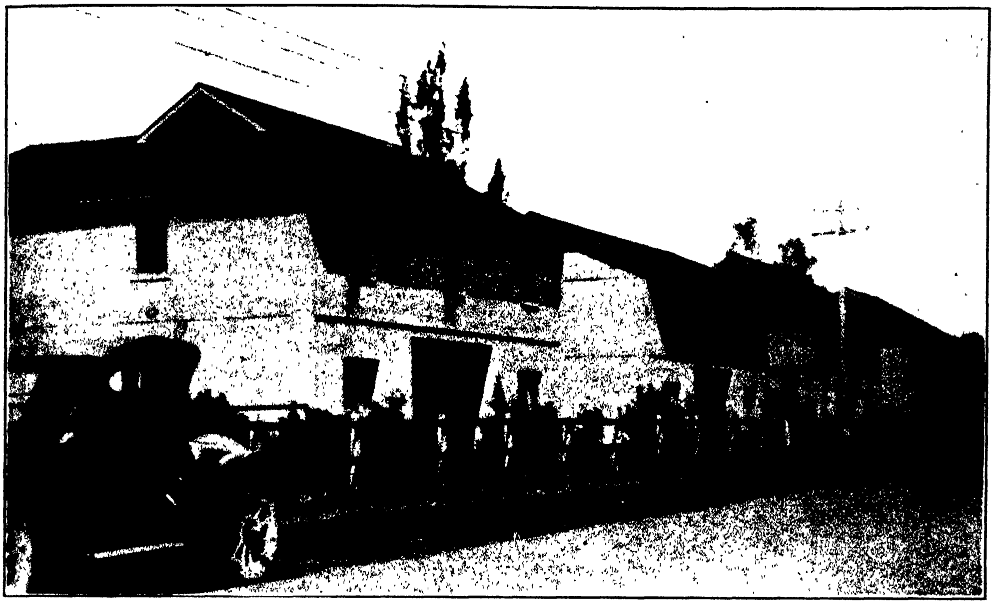
Examples of the Work of Plantation Improvement.

Industrial Service Bureau, H. S. P. A.



Group of dwellings occupied by semi-skilled employees on an Oahu plantation.

Group at baby nursery on a Maui plantation.



Laborers' concrete quarters, Island of Kauai.

Laborers' quarters on a plantation on Hawaii. Situated along the government road.

General Welfare Work.

By Donald S. Bowman,

Industrial Service Bureau, H. S. P. A.

The plantations in Hawaii have for many years been credited with having better housing and sanitary conditions on their estates than is the case in most countries of the world. Dr. Victor G. Heiser, Director for the East of the International Health Board, which operates under the Rockefeller Foundation, states that "representatives of the Foundation have visited plantations in many parts of the world, including Hawaii, and have found conditions probably more advanced in Hawaii than elsewhere." The plantations are today upholding their reputation for good housing, rapid advances being made to provide still better quarters.

Plantation laborers' community house on a Kauai plantation.

Better Living and Social Conditions:

Throughout the United States a movement for better living and social conditions for the laboring class has developed, resulting in the building of model settlements where trained social workers are employed to look after the general welfare of the workers. We are not behind in this splendid work, which has been carried on in some degree since the first plantation was started.

Industrial Service Organization:

The Hawaiian Sugar Planters' Association realized for some years that the general welfare work should be uniform and that there should be some central organization to act as a clearing house for information, promoting all branches of the work. The Industrial Service Bureau was created at the last annual meeting of the Association. As the title implies, the Bureau is to serve the plantations in any way that will promote and assist in the betterment of general welfare conditions. It is believed that suitable sanitary surroundings, proper modern housing, proper recreation in idle hours, an opportunity for education in conversational English through night schools and club rooms, will and do lead to increasing confidence in one another, and to a better understanding of industrial relations.

Community playground for children. A Kauai plantation.

Absence of Paternalism:

There should be an absence of paternalism in industrial relations on the plantations; labor should in no sense become an object of charity. All activities in social and athletic life should be self-supporting as far as they can be made so.

Welfare Worker:

The providing of community and club houses, amusement centers, etc., are in line with welfare policies that have proven well worth while here and on the mainland. However, we gather from the experience of others and existing conditions that the success of the work depends not so much on the equipment as on the worker. In other words, buildings and equipment are practically worthless to accomplish the desired results without a welfare worker in charge.

Better Housing:

The building of better houses on the unit housing system is acknowledged to be good business and results in contented families. When the strikers returned to work, those who had occupied the modern single-family houses were worried more over their houses than over their jobs, and their first request in many cases was for their former houses.

Sanitation:

Probably the best investment the plantation can make is to insure the workers' good health by providing sanitary and hygienic surroundings. This work should be of a permanent character in each village, and all plans for the disposal of waste water and fecal matter should be carefully worked out and should be submitted to the Bureau before work is started. Full information as to the different and approved methods of waste water and sewerage disposal may be obtained from the Bureau.

Water Supply:

A majority of the plantations hold certificates of approval of their water supply, issued by the Board of Health. To those that do not, and whose supply is subject to contamination, there is just one bit of advice—overhaul your water system and put it in such a condition that a certificate will be issued. This work is most important and should be accomplished ahead of other construction work which has as its object the betterment of welfare conditions.

Feeding:

Cafeterias, restaurants and boarding houses are best provided by or under the supervision of the plantations. There is no argument about the difference in the amount of work a well-nourished man performs as against one who is poorly fed. It is good business to see that the laborers are well fed, and where a sufficient number of men who are not capable of properly feeding themselves are employed, there should be some place where good, wholesome food is served. Should a man wish to live higher than the ordinary eighteen-dollar board, help him to find it. It is far better for him to spend his money on food than for nonessentials.

Food Supply:

In order to insure a supply of fresh food and encourage the raising of chickens, pigs, etc., by the labor, there are many ways in which plantations may help, a few of which are listed:

Assign each family garden space in a suitable location.

Provide a section for the raising of pigs, the best method being to locate the pens alongside of an irrigation ditch, the plantation putting in sanitary concrete floors for the pens, the pig-raisers building the sheds.

Set aside a section for chicken houses and runs.

Provide pure-bred stock to breed from, exchanging boars, etc., with the labor for their scrub stock.

Encourage the raising of vegetables, pigs and chickens by a campaign of education conducted by the Industrial Service or Welfare Worker.

Plantation Store:

The stores as a general rule are not conducted for profit and in most cases undersell their competitors dealing in staple food supplies. This is as it should be. However, the store should cater to the trade and should supply the merchandise demanded. With the present prosperity of the labor many articles of household and personal luxury are being purchased which should be carried by the plantation store.

Dairies:

One of the best investments from a health point of view is the providing of a dairy, in order that the plantation employees of all classes may be provided with pure milk at low cost. Milk is most necessary for the proper development of the child, and is one of the best foods that can be provided for adults. In times of epidemic, such as the recent outbreak of flu, the plantation that could and did furnish milk for the patients obtained the best results.

Meat and Fish:

The use of meat and fish should be encouraged, and the plantation would do well to see that proper supplies at a reasonable cost are to be had.

Amusements:

Amusement is craved by all nationalities, and life is dull indeed where no amusements are provided, especially on the isolated plantations. In providing amusements a careful study should be made and the tastes of the labor considered. They should be provided with what they want and that which will be most appreciated. The carrying on of amusement enterprises should be self-supporting in so far as the expenses of operation are concerned. The motion picture theatres and village club houses have proven most successful and should be installed in all the large settlements. The combination community house and hall for movies, vaudeville and other forms of entertainment is not desirable. It is far better to have the theatre a separate institution, the construction to be permanent in character, with a sloping concrete floor; good seats to be provided. Such a theatre could be used for movies, vaudeville, amateur shows and public meetings of all kinds.

Recreation:

The providing of recreation is a matter to be developed by the Industrial Service Worker on the plantation, and such activities as are demanded and patronized should be in every way encouraged. The best way of arranging a recreation program is by organizing the plantation employees into clubs, etc.,

they conducting the activities under the direction and with the assistance of the Worker. The most popular sports now conducted are baseball, basketball, volleyball, indoor baseball, and track events.

Boy Scouts:

Boy Scout Troops are a great asset to the plantation and go further in teaching Americanism than any other method known. This movement should have the support of everyone interested in the plantation.

Work With Women:

Much good may be accomplished in a practical way among the women and girls by the visiting nurse or woman Welfare Worker, some of the work carried on being the teaching of cooking, household management, care of infants and children, preparation of infant food, sewing, first-aid work, etc.

Education:

No man or woman can be fully competent unless he or she can understand orders and instructions which are given. Educational activities on the plantations should be, in so far as the labor is concerned, along lines that teach conversational English and Americanism. This work can be carried out by the Industrial Service Workers.

The ideas and suggestions presented in this article have all been tried out on plantations; and it is believed that the activities mentioned all tend to improve the morale of the labor and make the plantation a better place on which to live.

A quotation from Roosevelt expresses our sentiments better than any other words we could use: "Unless this country is made a good place for all of us to live in, it won't be a good place for any of us to live in."

An Entomological Inspection of the Kohala District.

By C. E. Pemberton.

The particular object of the trip, apart from general inspection, was to determine the abundance, distribution and injury, if any, of the wireworms which have been so numerous at Honokaa and Paauhau plantations. Soil was carefully examined about the cane fields of all the varieties of cane grown, in freshly planted fields, in young plant and in mature cane, at all elevations from the sea to the extreme mauka fields over the entire district, including the homestead plots above Hawi plantation, as well as Puakea Plantation Company. No evidence was found anywhere of wireworm injury. The wireworm, *Mono-*

crepidius exul, which has been so destructive at Honokaa, is very scarce at present in Kohala. Only one individual was found. This was an adult and indications are that it never has been numerous in Kohala. The blackish white click, or snap beetle, to which this wireworm transforms when fully developed, has never been noted in great numbers at lights about the houses, according to statements by various regular residents in the district. If it had ever been abundant, as at Honokaa, it would very likely be recognized and remembered by the plantation people.

The other species of wireworm, *Simodactylus cinnamomeus,* which has been rather uncommon at Honokaa, is also scarce at Kohala, but more numerous than the first species, *Monocrepidius exul.* The *Simodactylus* is a large, brownish snap beetle. It has been frequently seen at lights in Kohala. Altogether, during two weeks in the district, I found fifteen adults and one larva or wireworm of this species. The larva was found in a cane stool at Union Mill Company, in the ground, but was not feeding upon the cane. There is no indication that this species is injuring the cane in Kohala.

It will be remembered that during April we found grubs of Fuller's Rose Beetle, or Olinda Beetle, *Pantomorus fulleri,* abundantly present in the soil at Honokaa, and it was then considered possible that the great number of wireworms then present was owing to the existence of these grubs. It is known to feed upon other insects and it seemed possible that the wireworms accumulated here, or were attracted here in the adult stage, to avail themselves of the many Olinda Beetle grubs for food. I do not now consider this theory applicable to the situation, in the light of recent observations in Kohala. In all plantations of Kohala, including the homesteaders' fields, particularly above 500 feet elevation, I found the grubs of the Olinda Beetle very numerous—more so than at Honokaa—and adults also very common. Wireworms, however, of both species, though present, were exceedingly scarce.

On June 3, in a mauka field of Striped Tip at Union Mill Company, adult Olinda Beetles averaged about one per every twenty sticks of cane examined. Twelve grubs of the beetle were dug from the soil in ten minutes' time. The grubs of the beetle apparently do no damage to the cane, though they no doubt feed upon the tender cane roots. The exact amount of injury accomplished by them would be interestng to determine. The work is obscure and could be easily overlooked. The grubs actually destroy the roots and kill the plants of several berries and of roses in the States. The adult beetle eats conspicuous notches in the cane leaves, though very little actual damage was noted in Kohala by the adult. One wireworm and ten adults, all of the species *Simodactylus cinnamomeus,* were found in the above-mentioned field of Union Mill Company. The adults were found clustering in the foliage of a shrub near the cane. On the same date, in ten minutes of digging in the soil of homestead plantations above Hawi, fifteen grubs of the Olinda Beetle were found, and in following a tractor which was plowing this field, seventeen Olinda Beetle grubs were picked up in a few minutes' time. No wireworms were seen. On June 5, in an extreme mauka field of Halawa Plantation, ten Olinda Beetle grubs were dug from soil in a Striped Tip field in about five minutes' time. On June

7, in a mauka field of Striped Tip cane of Kohala Sugar Company, one hundred and forty-five Olinda Beetle adults were collected in 110 feet of cane row. The beetles were in the crowns of the stalks, or in the weeds about the stools. Larvae and pupae of this beetle were equally numerous in the soil of this field. From four small weeds (Verbena sp.) about three feet high, in this same field, fifty-one adult Olinda Beetles were collected. The beetle apparently prefers this weed to cane. No particular injury to the cane could be detected in this field where the beetles were so numerous. If there is injury, it will require a detailed and careful study, before proof can be shown. In spite of these large numbers of adult beetles and grubs, no wireworms were found. The Olinda Beetle does not fly and crawls very slowly. Fields that are free now can be expected to remain so for some time and vice versa. Olinda Beetles and their grubs were also common at Niulii and Hawi Plantations and at Kohala Sugar Company.

The *Scolia* parasite of the *Anomala* beetle was found established in Kohala. Two adults and one larva were found at Union Mill Company in a D 1135 plant field at about 500 feet elevation on June 12. The adults were flying over weeds adjacent to the field, one being captured for determination. This individual, which was a male, was sent to Mr. Swezey for final identification. The *Scolia* larva was found feeding on a Japanese beetle grub, about seven inches underground in this same field of cane. The beetle grub was about one-half consumed when the parasitic larva was found. It shows definitely that the *Scolia* is taking naturally to the Japanese beetle in Kohala and some benefit in the future is likely to result. Mr. Swezey writes that colonies of the *Scolia* wasp were sent to Kohala from the Experiment Station in January or February, 1918, and in July, 1919. From these shipments it became established and has no doubt been feeding and developing on the Japanese beetle ever since. It will very probably gradually increase. It forms an insurance for the Kohala plantations in the future, should the *Anomala* beetle ever accidentally reach Kohala from Oahu. There is no reason to expect the parasite to die out, now it is once established, as long as the Japanese beetle remains in the district for it to feed and develop on.

Leafhoppers are everywhere in Kohala. The situation in respect to this is interesting. It is present everywhere and the hopper eggs are well parasitized. The heavy wind and light yearly rainfall serve to keep the cane generally tough and hard. This checks the egg-laying of the hopper, and the parasites reach most of the eggs laid. The absence of rain enables them to attain their maximum degree of efficiency. At Union Mill Company on June 4, in a mauka field of 1921 Striped Tip cane, eighty-four hopper eggs were found in two hours of searching, 85.7% of which were parasitized by *Paranagrus optabilis*. In a makai field of 1922 Striped Tip cane of the same plantation, on the same date, seventy hopper eggs were found after three hours of searching, 88.5% of which were parasitized by *Paranagrus*. From 175 six-inch pieces of cane mid-rib of Yellow Caledonia cane of the 1921 crop, collected at Union Mill Company at 500 feet elevation on June 16, I secured forty-three hoppers, two hundred and thirteen *Paranagrus optabilis* and three *Ootetrastichus formosanus*. This represents a total parasitism of 84.1%. In mauka fields of 1922 Striped Tip cane of

Kohala Sugar Company on June 7, a total of one hundred and fifty-seven hopper eggs were found in one and one-half hours' searching. Of these, 85.9% were parasitized by *Paranagrus* and 0.6% by *Ootetrastichus formosanus*. In two hours' examination of mauka fields of Striped Tip cane, of the 1921 crop, at Niulii Plantation on June 8, a total of two hundred and thirteen hopper eggs were found, of which 90.1% were parasitized by *Paranagrus*. At Halawa Plantation on June 9, in a field of Striped Tip cane, 1921 crop, in the center of the plantation, four hundred and eighty-eight hopper eggs were found after three hours of searching. Of these, 84% were parasitized by *Paranagrus optabilis*, and 10.2% were parasitized by *Ootetrastichus formosanus*. This is a high parasitism, totaling 94.2%. At Hawi Plantation, hoppers were generally scarce, and wherever eggs were examined the parasitism averaged much the same as at the other plantations.

To obtain definite figures on the abundance of adult hoppers over the district, all hoppers found in an average field at Union Mill Company, at 500 feet elevation, were counted, that could be found in two hours of constant searching. A total of eighty-seven were found. Five of these were parasitized by *Dryinid* parasites and one adult *Dryinid* was found of the species *Pseudogonatopus hospes*.

The trash-feeding beetle *Gonocephalum seriatum*, a short, broad, black, slow-moving beetle, present in the soil about the cane, is exceedingly prevalent in the cane fields of Kohala. The larvae of this beetle—a so-called "fake wireworm"—is very common in the soil. It greatly resembles the true wireworms and may be easily confused with them. It forms a definite and conspicuous part of the insect fauna of many cane fields, particularly in Kohala at present. It was so numerous here that an attempt was made to record the extent to which it occurs in the fields. A total of five hundred and twelve larvae of this beetle were collected in a day's time on July 11, at Union Mill Company, in a field of D 1135 plant cane, of the 1922 crop, in a small area amounting to less than one-quarter of an acre. These larvae have been saved for further investigation. The food habits of a soil-inhabiting beetle so common in the cane fields, need further study. It probably feeds only on decaying cane and weed roots and other vegetable matter in a decomposed condition. An attempt will be made later, when opportunity affords, to secure definite data on its food habits. There is a possibility that it may take living cane roots to some extent. It feeds readily on raw potato in confinement. It is checked somewhat on Oahu by a parasite. I saw none of this parasite in Kohala.

Pythium in Relation to Lahaina Disease and Pineapple Wilt.

By C. W. Carpenter.

The so-called Lahaina disease or deterioration of the Lahaina variety of cane in Hawaii has been of general concern to cane planters since about 1909, when serious damage became evident at Ewa Plantation. Since then the disease has manifested itself more or less seriously on Maui and Kauai and throughout the Puuloa and Pearl Harbor sections of Oahu; and more recently on the mauka virgin lands of Oahu Plantation, where the variety H 146 also failed signally in certain areas. There is little doubt, however, that the same disease was responsible for the much earlier failure of the Lahaina variety on the Island of Hawaii.

Similarly we find in the literature references to the deterioration of Bourbon (Lahaina) and Cheribon cane, etc., in other countries, including Java, Mauritius and the West Indies, the descriptions and observations made strongly indicating that the same conditions obtain almost wherever sugar cane is grown. The pineapple "wilt" disease, now so prevalent locally, offers a parallel case in its history.

While no attempt will be made here to review the pertinent literature completely, it is not out of place to cite the experience of other countries with these diseases, and to bring together certain facts which illustrate their conflicting nature. Some writers have held the view that cane varieties are not stable and that they run out after a varying period. It is not denied that there is considerable evidence in support of this view. It is not proposed to take up the question of varietal deterioration[1] extensively, but only as such deterioration appears to bear a relation to our Lahaina deterioration.

In this paper the writer proposes to cite some facts as to the occurrence of this type of disease, facts relating to the character and symptoms of the disease, together with some theories as to the cause which have been advanced. Some experimental evidence in support of the *Pythium* theory is presented, together with plates illustrating the work.

No attempt is made to consider other cane root rots, such as the one attributed to *Marasmius sacchari*, etc., though perchance some confusion exists in the literature and will find its way into these remarks. Root rot is a general term applied to root troubles in general as well as to certain diseases of the roots where no cause can be demonstrated, and thus the above-ground symptoms of the plant may result from a variety of causes. In this paper the term root rot is used in a restricted sense and refers specifically to the type of disease represented by "Lahaina disease" and pineapple "wilt." These diseases are removed *pro tem.* from the category of "physiological" root rots and an at-

[1] Cf. Planters' Record IX, p. 462 et seq., 1913.

tempt is made to demonstrate that the determining cause is a specific fungus of the *Pythium* type.

PART I — HISTORICAL.

Regarding the so-called deterioration of varieties of sugar cane, notably the Bourbon, apparently the same as our popular Lahaina variety, there exists a considerable literature scattered through tropical agricultural journals, etc., only a few articles of which the writer has been able to consult. So far as these articles refer to the deterioration of the Bourbon cane and similar cases, there is a marked similarity to our experience with the Lahaina cane in Hawaii.

Similarly in the literature we find references to the disease called pineapple "wilt." Whether the disease or condition is the same as we are experiencing with this crop cannot be definitely stated. No doubt there are several conditions which bring about the "wilt" symptoms, such as impoverishment, dry weather, and nematodes, in addition to the obscure malady we are investigating in Hawaii.

A few extracts are quoted below from the literature which support the assumption that we are not dealing with a problem peculiar to Hawaii. For the history of these diseases as they occur in Hawaii and for other references to the literature of the subject the reader is referred to the various Bulletins of this Station, and to the articles in the Planters' Record by Cobb, Agee, Lyon, Larsen, Burgess and others.

Sugar Cane.

British West Indies. A few paragraphs on varietal deterioration are quoted from "Sugar Cane Experiments in British Guiana," by Harrison, Stockdale and Ward.[1] (p. 177 *et seq.*):

> "In all over eighty so-called varieties of sugar cane were collected together and these were finally grouped under forty-four names. . . . Despite our efforts nineteen varieties have died out since 1890. . . . They have received similar treatment to plant canes and to ratoons on sugar estates in the Colony. . . . They have been replanted every few years, and thus it may be accepted that they have been under estate treatment. Is this loss of nearly half of the varieties from a collection not of significance? The deterioration of the Bourbon[2] variety of sugar cane has been remarked by every sugar planter in British Guiana and probably in every one of the British West Indian sugar-cane growing colonies, but our experience as above indicated shows that this deterioration is not confined to the Bourbon and to certain seedling varieties.
>
> "The gradual falling off of the Bourbon cane commenced in 1896 and became very appreciable in 1904. . . . The falling off of the Bourbon variety, the old standard sugar cane of the colony . . . was a gradual one. . . . One of the earliest symptoms of 'running out,' 'falling off' or 'degeneration' was a reduction in its capacity for responding to treatment with nitrogenous manure. There was also a change in the color of the foliage and a very apparent falling off in vigor.

[1] West Indian Bulletin, Vol. XIII, pp. 95-218--Harrison, J. B., Stockdale, F. A., and Ward, R. 1913.

[2] Lahaina.

"The falling off here illustrated must not be confused with the gradual falling off in yield normal to the cultivation of any variety of sugar cane where the practice of long continued ratooning is followed. . . . Two of us, in 1905, were called into consultation as to the condition of the canes on a certain estate. . . . The Bourbon variety was practically the main variety cultivated. The whole of the Bourbon canes were very seriously diseased, and in fact some fields were so badly affected that the canes were not taken to the mill. The proprietors seriously considered the abandonment of the estate, but by the substitution of seedling varieties, notably D 625, for the Bourbon variety, the estate has been entirely rejuvenated. . . .

"It is almost unnecessary to point out that under favorable conditions of growth the duration of useful life of a sugar cane may be materially lengthened, that a change of soil and environment may brace it to renewed vigor and that whilst a sugar cane may suffer from 'running out' or senility in one locality it may be in full vigor of life and vegetative activity in another.

"An argument which may be adduced in the case of the Bourbon cane against this theory of running out or senility, is that it had been under widespread and long continued cultivation in British Guiana until about 1895 without showing any sign of degeneration. But the records of other sugar-growing countries show that the Bourbon cane has run out in the majority of them and its cultivation has had to be largely curtailed or abandoned. The running out has occurred after very varying lengths of cultivation in different countries. It occurred in Queensland as long ago as 1872, when the variety had been there in cultivation only a comparatively few years. Its effects commenced to be marked in the Northern West Indian Islands early in the nineties of the last century, probably preceded somewhat in Barbadoes, where its cultivation had been the most intensive . . . and followed a little later in St. Vincent."

Further on the statement is made:

"The more noticeable points are that the susceptibility of the Bourbon cane to fungoid attacks is far in excess of that of any other variety now under cultivation in the experimental fields."

Java. Regarding the occurence of root rot of cane or "Wortelrot," in Java, we may quote Lyon:[1]

" 'Wortelrot' has been known for many years in Java and has received considerable attention from plant pathologists. In 1903 Kamerling published a book of some 200 pages dealing with various aspects of the subject, but supplying no tangible conclusions.

"In Java the trouble does not appear to any extent in the young cane, but comes on when the plants are about two-thirds grown. In this connection it should be noted, however, that the cane makes its early growth during the rainy season and 'Wortelrot' appears in the dry season.

"While in Java I made a careful study of this trouble and the work which had been done upon it by the Java pathologists. The following paragraph is taken from my notes made at that time:

"Canes are apt to die off early in the dry season; this is especially true of some varieties, i.e., Cheribon. Their root system fails to per-

[1] Lyon, H. L.—Planters' Record XII, No. 5, pp. 297-298, 1915.

form its proper functions; the old roots die and no new ones are produced, and consequently the cane dries up. They look upon this in Java as due to the aging of the cane, or lack of vitality due to old age. Miss Wilbrink says it is not caused by a fungus even in part. When the cane begins to die of 'Wortelrot,' watering will not save it or seem to help it."

Sorauer[1] has the following to say about the root rot of cane:

"Among the numerous diseases of sugar cane, root rot plays an important part. In Java it is considered the worst enemy of sugar-cane culture. Naturally growers have not failed to cite the microroganisms [*Verticillium* (*Hypocrea*) *Sacchari*, *Cladosporium javanicum* Wakker, *Allantospora radicicola* Wakker, *Pythium*, etc.] colonizing on the diseased roots as its cause. Nevertheless, Kamerling's[2] recent experiments have now confirmed beyond all doubt the supposition that a constitutional disease is concerned here, resulting from compacting the soil. Raciborski, with Suringar,[3] has expressed the theory, earlier proved, that by transplanting sugar cane which had suffered from the root disease known as 'Dongkellanziekte' to other soil, the plants would become healthy. The disease occurs especially in heavy clay soils and manifests itself in Java, when at the beginning of the spring monsoon the plants die with alarming rapidity after they have already shown for some time an abnormal branching of the roots and also deformed root hairs. He investigated the soils in which the disease occurred and found that they did not have sufficient friability and easily became compacted. The permeability of the soil can be increased by supplying humus, since this, as also ferric hydroxid or silicate rich in iron, favors the formation of friable soils. Since the humus is gradually lost by oxidation, care must also be taken to retain the porosity of the soil by a renewed supply of stable manure, rice straw or green fertilizer (compost)."

That a fungus of the *Pythium* type has previously been observed in cane roots is indicated by the following extract from Wakker and Went[4]:

"In the first treatise on sereh disease Treub[5] mentions, besides an Heterodera (nematode) . . . a mold found by him on the roots of sereh diseased cane.

"He classifies this mold as most probably belonging to the genus *Pythium*, with which it really has some resemblance, and the consequence was that in the later literature on sereh disease the presumptive *Pythium* is always mentioned as the probable cause of sereh. Strangely enough, no close investigation was made until 1891, when Tschirch published an article wherein he classifies the above mentioned mold under the endotrophic mycorhiza of Frank. It seems to me that he is right. True enough, Treub states that when pieces of the root containing the fungus are placed in water, certain swimming spores which belong to the *Pythium* type appeared, but about any relation between the two nothing can be found in his treatise. I would suggest that the name

1 Sorauer, P.—Manual of Plant Diseases, Vol. I, pp. 228-9. 1905-1909. Translation by Frances Dorrance. 1915.

2 Kamerling, Z.—Verslag van het Wortelrot Onderzoek, Soerabaia. 1903.

3 *In* "Mededeelingen van het Proefstation vor Suikerriet in West-Java," No. 48. *Cit.* Zeitschr. f. Pflanzenkr., 1901, p. 274, and 1908, p. 88.

5 Treub, M.—Onderzoekingen over Sereh-ziek Suikerriet. Mededeelingen uit s'Lands Plantentuin II. 1885.

Pythium for our first root mold be dropped and for the time being simply call it Root Fungus No. 1.

"The following are my personal observations regarding this peculiar fungus. When examining the thin roots of the sugar cane we nearly always find strong, winding, thick-walled fungus threads inside the cells. Treub mentions the same about the roots of sereh diseased plants. In certain preparations I saw that they were connected with similar fungus threads which run between particles of the soil. . . . As Treub describes and as roughly sketched by Tschirch, the threads often form close clews in the deeper cells of the cortex. Here they are always thinner than the first mentioned threads and often they are difficult to find on account of the protoplasm of the attacked cells having changed to a crumbling mass of low transparency. The mold threads themselves having died off here and there. . . . Cross walls appear here and there, but always as an exception. Except in the soil and in the cortex cells of the thinner roots, I have never found this fungus.

"At the ends of the threads, both in the soil and in the surface cells, round objects are found, sometimes deformed by the shape of the cells to a more or less cylindrical form. At first sight they look like propagation organs. . . . Sometimes these round bodies have thick walls, wherein different layers can plainly be distinguished. . . .

"While Treub considered this fungus a parasite causing the death of badly infected plants, Tschirch believes, in accordance with the theory of Frank (endotrophic mycorhiza), that the cane is not injured by this fungus, but that by symbiosis it may be useful to the plant. There is no proof, . . . and I believe it better to classify this fungus with the parasites.

"It is quite true that once in a while a strong development was found in dead roots (*Saccharum ciliare*), but there was no proof that the fungus was the cause of death, and cannot very well be furnished as long as *pure cultures of the fungus are not known. So far nobody has succeeded in obtaining these.*[1] I only want to add that no root fungi are found in the roots in sterilized soils."

Besides the deterioration of variety or senility theory, brought out in a previous section, many theories have been more or less thoroughly investigated, especially in Hawaii. Although a theory of a fungus or other parasite as a cause has been advanced before in other countries as well as Hawaii, to the writer's knowledge no experimental proof of parasitism has been obtained. It is not proposed to review the various theories in detail, but merely to cite them and the apparent conclusions reached, if any, to illustrate the elusive nature of the problem, and the attention the disease has received.

Among the theories advanced and rather completely investigated in Hawaii are the following:

1. Attacks of parasitic organisms.
2. Senility, deterioration or running out of variety.
3. Root rot.
4. Soil toxins.
5. Lack of available plant food.
6. Bacteriological relations.
7. Black alkali.

[1] Italics, the present writer's.

Cobb[1] took up the study of root disease of cane in Hawaii, and considered such fungi as *Ithyphallus, Clathrus, Dictyophora*, and *Marasmius*. *Marasmius sacchari* is generally accepted as a cause of a certain type of root rot. As to the causal relation of species of *Ithyphallus*, *Dictyophora* and *Clathrus* to the disease of cane under investigation, to which fungi much of the damage was attributed by Cobb, no proof was offered.

Amongst a wealth of detail, the abilities of the fungi as parasites were neglected. At the most *Ithyphallus* is claimed by Cobb to be a wound parasite.

Lyon[2] attacked the problem from the first three angles above mentioned: Parasitic organisms, senility, root rot. He summarizes his investigations as follows:

> "Careful microscopic and cultural studies, however, though long continued and oft repeated, failed to reveal any parasitic organism which could possibly be responsible for the disease. The transfer of diseased roots to the soil about the roots of healthy canes failed to transmit the disease. Cuttings from diseased plants produced strong, healthy stools when planted in other soil. Diseased stools recovered when transplanted to other soils. As a result of these studies and experiments we were forced to conclude that the trouble could not be ascribed to parasitic organisms."

As to the senility theory, that Lahaina cane

> "has not lost its ability to grow and produce as large and vigorous cane as ever, if its present requirements of soil, temperature and moisture are satisfied, is amply demonstrated by the following history of a few stools of Lahaina cane:
>
> "The stools mentioned were some of the worst that could be found at Waipio. They were dug out and with the soil clinging to the roots were planted at Honolulu (May 21).
>
> "By the end of the summer these stools had produced a perfect stand of as healthy Lahaina cane as could be found anywhere in the Islands.
>
> "The nearly dead, constricted, original sticks resumed growth and became nearly as robust as the sticks from the new shoots. Some of the constricted sticks grew 15 feet after being transplanted.
>
> "This little experiment would seem to effectually eliminate senility and parasitic organisms as plausible explanations for the Lahaina disease. . . . Lahaina disease must therefore be diagnosed as Root Rot. Its correction is a problem in soil sanitation."

In subsequent work, Lyon[3] detected the resting spores of an organism said to belong to the *Chrytridineae*, in the roots of cane and pineapple. Almost simultaneously with the present writer[4] the theory was advanced that both Lahaina disease and pineapple "wilt" were possibly caused by the same organism. Subsequent work[5] on the *Pythium* theory by the present writer in-

1 Cobb, N. A.—Pathological Bulletins 5 and 6. H. S. P. A. Experiment Station.
2 Lyon, H. L.—Planters' Record, Vol. XII, pp. 299-304. 1915.
3 Lyon, H. L.—A preliminary report on the root rot organism. Planters' Record, Vol. XXI, pp. 2-8. 1919.
4 Hawaii Agricultural Experiment Station. Press Bul. No. 54. 1919.
5 L. c.

dicated that the resting spores studied by Lyon were identical with the resting spores of the *Pythium* type fungus.

Peck and Agee[1] investigated the Lahaina disease on the theory of soil toxins and tried a number of soil treatments, including different forms of lime, carbon black, pyrogallic acid, green manuring, fallowing, etc. The character of growth of Lahaina cane in affected soil, virgin soil, sterilized affected soil, sterilized virgin soil, and mixtures of 80% virgin soil and 20% affected soil, was observed. Sterilization of affected soil resulted in an increased growth. Leachings from affected soil failed to induce disease in plants watered therewith. The most encouraging results from Peck and Agee's experiments were the gains of plots where green manuring was practiced over fallowed plots.

Burgess[2] found some correlation between the occurrence of Lahaina disease and the presence of black alkali in the soils. In his opinion black alkali is not the only cause of Lahaina disease, but is doubtless a contributing factor.

As to available plant food, Burgess concludes: "Lahaina disease cannot be attributed to lack of available plant food. In many cases more is present under the poor cane than under the good."

Some work was done by Burgess along bacteriological lines, with results as indicated by the following quotation:

> "From the bacteriological work which has been done on these soil samples it is very evident . . . that we must turn activities in other directions are we to find the true cause for the deterioration of Lahaina cane on Maui, Oahu and Kauai."

Pineapple.

It should be emphasized again (cf. p. 142) that we have no satisfactory means of determining readily the disease termed "wilt" of pineapples and differentiating the epidemic disease from those other diseases or conditions resulting from poor soils, lack of water, malnutrition, etc. Besides examining the plants one must be familiar with the field from which the plant is removed, and preferably make a field examination before an opinion can be hazarded. Like the term root rot in the broad sense, "wilt" is a collective term, but we are attempting to limit its meaning in this paper to a narrow sense, signifying a spreading and destructive disease, which gives evidence of being parasitic in origin, at least in part.

An article by H. T.[3] in the Queensland Agricultural Journal furnishes a rather comprehensive account of a pineapple disease occurring in Queensland, which suggests the "wilt" of this crop as we know it in Hawaii. This article, while comprehensive as to observations on the disease, is unfortunately very superficial as to facts from experimental evidence, and as to the fungus mentioned as associated with the disease, nothing is furnished in the way of a description from which we can determine what sort he observed. Some signifi-

1 Agee, H. P.—Planters' Record XII, pp. 374-389. 1915.

2 Burgess, P. S.—Planters' Record XIV, pp. 303–326, 353–370. 1916.

3 H. T. (Tryon ?)—"The Pineapple Disease," by H. T. Queensland Agricultural Journal, Vol. XV, Part 1, pp. 477–485. 1904.

cant statements which may have a bearing on our pineapple problems are quoted below:

"In 1887 the growers of pineapples at Mundah, . . . became greatly concerned on discovering that these plants were failing, and this in spite of all effort to obviate so undesirable a contingency. And they even anticipated that the fine orchards there would be extinguished if this affection continued to spread as rapidly and extensively as it had recently done. These expectations have not been realized; but nevertheless pineapple growers have in some instances ever since then experienced by reason of its occurrence considerable annual loss . . . the malady complained of has not been general in the district, and even those growers who have had to lament its presence are already persuaded that, as has happened in the past and so may transpire in the future, their cultivations will become free of it. All . . . will welcome an exposition of its true nature and of the circumstances which determine its capricious occurrence at particular seasons and in definite and special localities.

". . . it may be remarked that pineapples when affected by this disease in question present the following distinctive features: Their ordinary somewhat darkish-green hue gives place to one in which red and yellow predominate; or, owing to the wilting and twisting of the leaves from their points downwards, a brownish tint pervades the plantations . . . the leaves have lost to a certain extent their usual turgidity; they lack the full rigidity so characteristic a feature in the leaves of the healthy pineapple plant; and if they bear fruit at all, this has already assumed a yellowish hue long prior to the time when under ordinary circumstances it should do so. As usually happens there are far more pronounced symptoms of decadence, for the plant has both commenced to die back and become rotten. The apical leaves and shoots have either already fallen away or may readily be removed *en masse* by the hand for . . . they are already decayed at their bases of attachment. . . . On lifting from the ground a plant presenting these symptoms, it will be found that the roots proper and rootlets are already dead and in an advanced stage of decay, and that no new ones are succeeding them. A longitudinal section through a pineapple plant in which the disease is not far advanced reveals the fact that as regards its external manifestations decay has commenced at the growing apex, proceeding thence downwards into the stem.[1] Further inquiry will render it evident that very early in the history of the disease, and even when these external symptoms are still unmanifested, the roots or rootlets have already perished. . . .

"In the earliest indication of root disturbance encountered both roots and rootlets are normal in appearance, but the microscopic hairs which so thickly clothe them, instead of being obtusely pointed simple cylinders, are terminally widened and twisted. . . . Then, as an illustration of further development, the pineapple plant has its roots and rootlets discolored at the tips, and tending to collapse on pressure on this situation. Then occur plants the roots of which are terminally pale brown, collapsing readily on pressure, instead of being white and resilient . . . this extends upwards along the course of the root. . . then finally we meet with plants in which the roots are all decayed.

"If suckers derived from badly affected plants . . . are planted under certain conditions as regards soil, they will not exhibit the dis-

[1] Apparently a confusion of top rot with wilt, or else the "wilt" in Queensland has different symptoms than in Hawaii, possibly due to difference in climate.

ease on becoming established, and will, moreover, produce healthy plants . . . the disease occurs quite spontaneously in plantations without any circumstance existing to favor the supposition that it has originated through infection. Further, it cannot be communicated at all or only exceptionally. Again roots may commence to decay in the manner indicated, and then the process stops, new lateral offsets arising to take on the functions of those organs which they replace. Thus it would appear that the inception and continuance of the disease is determined by certain conditions apart from those furnished by the plant itself.

". . . it may be remarked that some of the oldest growers are of the opinion that the pineapple plants, as being the progeny of one stock, are in gradual process of deterioration. . . . As a matter of fact, however, plants from remote localities have from time to time been introduced, yet without such results following their introduction as the advocates of 'new stock' are wont to anticipate.

"Commonly, the disease selects the young plants in preference to the old,[1] and this circumstance is similarly accounted for, also must not be forgotten that the critical period in the life of the pineapple is during the second and third years of its existence.

"When no other conditions obtain which tend to impair the healthy vitality of almost any plant, but especially the pineapple, it may be observed that certain classes of soil especially favor the disease—namely, those in which the water remains near the surface, either (1) owing to its inability to percolate to lower levels by reason of the presence of an impervious subsoil, or (2) too ready connection with lower water-bearing strata owing to some special property in the subsoil facilitating capillarity.

"Thus there are two different classes of soil in which plants subject to the disease occur, a circumstance which has given rise to the opinion that the character of the soil in no way influences its presence. Abundant evidence, however, confirms the opposite conclusion.

"Cultivations in which the disease is general have their soil answering to one of the following descriptions:

"(1) A shallow, sandy loam with clay subsoil.

"(2) Soil of good depth, largely composed of sand, becoming paler downwards and resting on clay.

"(3) A more or less argillaceous[2] shallow soil (18 inches) resting on clay.

"(4) Pale colored clayey loam, but 1 to 6 inches deep, resting on clay.

"The following soils grow pineapples free from disease:

"(1) A reddish brown or red loose deep soil, with or without small ironstones, resting upon an open ferruginous 'cement.'

"(2) A rich open loam, of considerable depth containing little free sand.

"It happens that some of the soils, though when wet weather prevails they determine, owing to their excessive moisture, the presence of the disease, are especially suitable for the growth of the pine, and yield heavy crops in time of drought, and this is especially the case when the impervious clay pan is some depth from the surface. All soils are, however, improved as far as relates to the growth of the pineapple plant by artificial drainage, and diseases will in many cases give place to healthy growth wherever this is properly carried out.

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[1] There are plants 30 years old which show no symptoms of disease.
[2] Clayey.

"The conclusion of the whole matter is, then, that the disease of the pineapple plant is caused by a special fungus which lives at the expense of and so destroys the roots—a fungus which is secondary, the injury being primarily occasioned by the soil not being in a condition for healthy growth."[1]

The following remarks are abstracted from an article on pineapple wilt by W. Nowell:[2]

"An affection of pineapple plants occurring on trial plots at Grove Botanic Station, Montserrat, has recently received attention. . . . The plants are of local stock (Ripley) . . . the first indication is a reddening of the foliage, which later becomes strongly marked, and the leaves wither from the tip downwards. More than half of the quarter-acre plot is now affected, and the disease continues to spread. Its progress is not very rapid: The general appearance is that of a slowly progressive drooping and wilting of the leaves, accompanied by a loss of color and ending in the complete drying up of the plant. . . . It is quite certain that the malady spreads to plants adjacent to those first affected. . . .

"In the specimens under consideration there are present in the roots from an early stage of their failure, fungus hyphae occupying the vessels, and the presence of hyphae is referred to by most writers on the subject. Most commonly the fungus referred to is a *Fusarium*. . . . The presence of such fungi on the roots is not of much value as evidence of their pathogenic nature. . . . The evidence which is most suggestive of a parasitic origin for the disease is that with regard to its communication from one plant to another, but in this respect the evidence from different countries is conflicting.

"There are two sets of ideas, more or less opposed, with regard to the nature of this disease. (a) That it is due to infection. . . . (b) That the disease is primarily due to some unfavorable conditions of growth.

"In the case of the beds at Grove Station there is no unfavorable factor apparent. . . . On the other hand none of the specimens examined from 1907 to the present time has revealed the presence of any parasitic organism adequate or constant enough to account for the affection."

Smith[3] states:

"In practice we have reason to believe that a diseased stock will prove a center of infection.

Lucas:[4]

"In a field of Ripley pineapple plants after the wilt makes a start, no matter how small the affected area might be, it will in an incredibly short space of time spread over acres, and in a few months will completely kill every plant, no matter whether the plants are old or young; but this disease seldom allows a plant to become of any age before it completes its work of ruin."

[1] NOTE:—No experimental evidence is offered in support of the above views by H. T.—(Author).

[2] *In* The Agricultural News, Vol. XV, No. 367. 1916.

[3] Smith, C. E.—Bulletin Botanical Department, Jamaica, IX, 161. 1902. West Indian Bul., IV, 110. 1904.

[4] Lucas, F. L.—Bul. Dept. Agric. Jamaica, V, 41. 1907.

PLATE I.

An early experiment which indicated that the Lahaina disease could be prevented by sterilization of the sick soil by either steam or formalin. It also indicated that bagasse exerted a favorable influence. Tub experiments with sick Waipio soils. Root systems, Lahaina cane, age 3 months. No. 2-3—Natural sick soil. No. 9—Disinfected seed, natural sick soil. No. 12—Disinfested seed, steamed sick soil. No. 5-6—Steamed sick soil. No. 30—Sick soil 63/64 parts; bagasse 1/64 part, by volume. No. 36—Sick soil disinfected with formalin.

According to Nowell, the Red Spanish variety in Montserrat is quite immune to the "wilt" disease, in contrast to the Ripley and all the other members of the Queen family.

Larsen[1] holds the following view:

> "The malady as occurring in Hawaii does not seem to spread from one plant to its neighbor, but appears in a sporadic manner."

Since 1910, however, we have had several sections in which there can be little doubt of spreading, i.e., Kailua section, virgin land and plant crop in 1918–1919, and similar epidemic manifestations in 1919–1920, in various parts of the Islands, indicating a change in nature of the disease.

PART II — EXPERIMENTAL.

Since the publication of the writer's preliminary report[2] on root rot of cane (Lahaina disease), pineapple (wilt) and other crops in Hawaii, the experiments reported therein have been largely repeated, with identical results. During the past six months, while the investigation of the root rot problem has been carried on at this station, further interesting observations have been made.

It will be recalled that upon taking up the investigation of the root rot of cane, the theory was advanced that "Lahaina disease" and pineapple "wilt," as well as several other diseases of Hawaiian crops, were essentially of the same origin and were induced by a fungus allied to the genus *Pythium;* that "Lahaina disease" and pineapple "wilt" diseases were essentially the results of a "damping off" of the roots under suitable soil conditions.

In this section of the paper it is proposed to collect recent miscellaneous observations on the root rot problem which have been recorded in the monthly progress reports, together with a discussion of the present status of the "Lahaina disease" and pineapple "wilt" problems.

Evidence Supporting the *Pythium* Theory.

In order to be convincing, experimental research seeking to establish the fact that a specific fungus causes a certain disease, must satisfy some fundamental requirements. Among the most important of the requirements set up by pathologists in this respect are the following: (1) Constant association of the fungus with the disease in sufficient quantity to make it plausible that the fungus is the cause. Presence of the fungus in and about the healthy tissues at the border of the lesions, and apparent ability of the fungus to attack healthy tissues rather than merely to inhabit dying or dead tissues. (2) Parasitism. Ability of the fungus to produce the characteristic symptoms of the disease when brought by means of pure cultures into contact with susceptible host plants, and inability of other associated fungi to produce the symptoms. (3) The successful reisolation of the specific fungus from the artificially induced lesions of inoculated diseased plants, and the successful inoculation of sus-

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[1] Larsen, L. D.—Pathological Bull. 10, this Station. 1910.
[2] Press Bulletin 54, Hawaii Agricultural Experiment Station, December 9, 1919.

PLATE II.

"Resistant" Demerara 1135. Tip of root showing resting spores and other stages of the *Pythium* type fungus. Soil inoculated.

Fig. 1 ×200 Fig. 2 ×500

Crushed root tips of D 1135 growing in steam sterilized soil inoculated with the *Pythium* from Lahaina cane. Similar results accompanied root injury in H 109 and Yellow Caledonia, indicating that the resistance of these three varieties is relative, not absolute. The large number of spherical resting spores and associated swollen mycelium are illustrated. Such conditions are found in Lahaina cane and pineapples, both in the inoculated soils and in the field.

ceptible plants with the reisolated fungus. The investigation of points (2) and (3) can be prosecuted *ad libitum*, until the investigator himself is assured of the causal relation of the fungus to the disease, and that no other fungus associated with the disease will produce the symptoms under the same artificial environment he may have to set up by the very nature of the problem.

With pathological problems, the extent to which it is possible to meet these requirements varies. Owing to the capricious character of this disease, no satisfactory scheme for inoculation of plants under natural field conditions has yet been devised. As can readily be seen from the following statement of our present knowledge, as demonstrated by the writer's experiments, these requirements have been met sufficiently to warrant further active consideration of the theory, if indeed they do not warrant acceptance of the soundness of our hypothesis. With respect to the requirement, "constant association of the fungus with the diseases," the evidence is still meager. Only extended observations can satisfy this requirement. For reasons given below, it may for a long time be difficult to demonstrate the fact of constant association of *Pythium* with the root rot diseases of pineapple and cane.

Association of Pythium with Lahaina Disease and Pineapple Wilt.

In seeking to locate the possible cause of root failure, which was earlier determined by various investigators to be the fundamental reason for the above-ground symptoms of disease in cane and pineapples, there was little success. Since no parasite could be detected, the diseases have been variously attributed to unsanitary conditions of the soil. This has been interpreted to mean physical or chemical conditions of the soil unfavorable to the plants, such as the presence of injurious chemicals, or plant toxins, or absence of necessary chemical elements, etc.

A working hypothesis which has been drawn up by the writer for further investigation of the problem takes into account the suspected elusive and transient features of the fungus deduced from the capricious occurrence of the diseases. The conflicting history of the diseases furnishes a basis for assumptions which are as follows: (1) The organism is active periodically (cf. temperature considerations, p. 172); (2) the symptoms of disease as observed on the above-ground portions of the plants are manifested after a greater or less time subsequent to actual root failure; (3) and that *at the time* the plant has noticeable symptoms of disease the affected roots are in such an advanced condition of disease that the parasite can be detected, perchance, only after painstaking search, and if present at all *then* is not a conspicuous occupant of the roots. In other words, root failure is not necessarily coincident with above-ground symptoms, but in greater or less degree correlated with the seriousness of the gross symptoms, has preceded the manifestation of the latter by a greater or less period of time.

It is perhaps significant in this connection that with cane symptoms of root failure arouse general interest in the fall months and winter, while with the pineapple, the symptoms are perhaps most alarming in the spring months.

PLATE III.

Lahaina cane, age 4½ months. Sick Waipio soil steam sterilized. At left soil inoculated with *Pythium* type fungus; at right uninoculated control. Three and one-half months after inoculation.

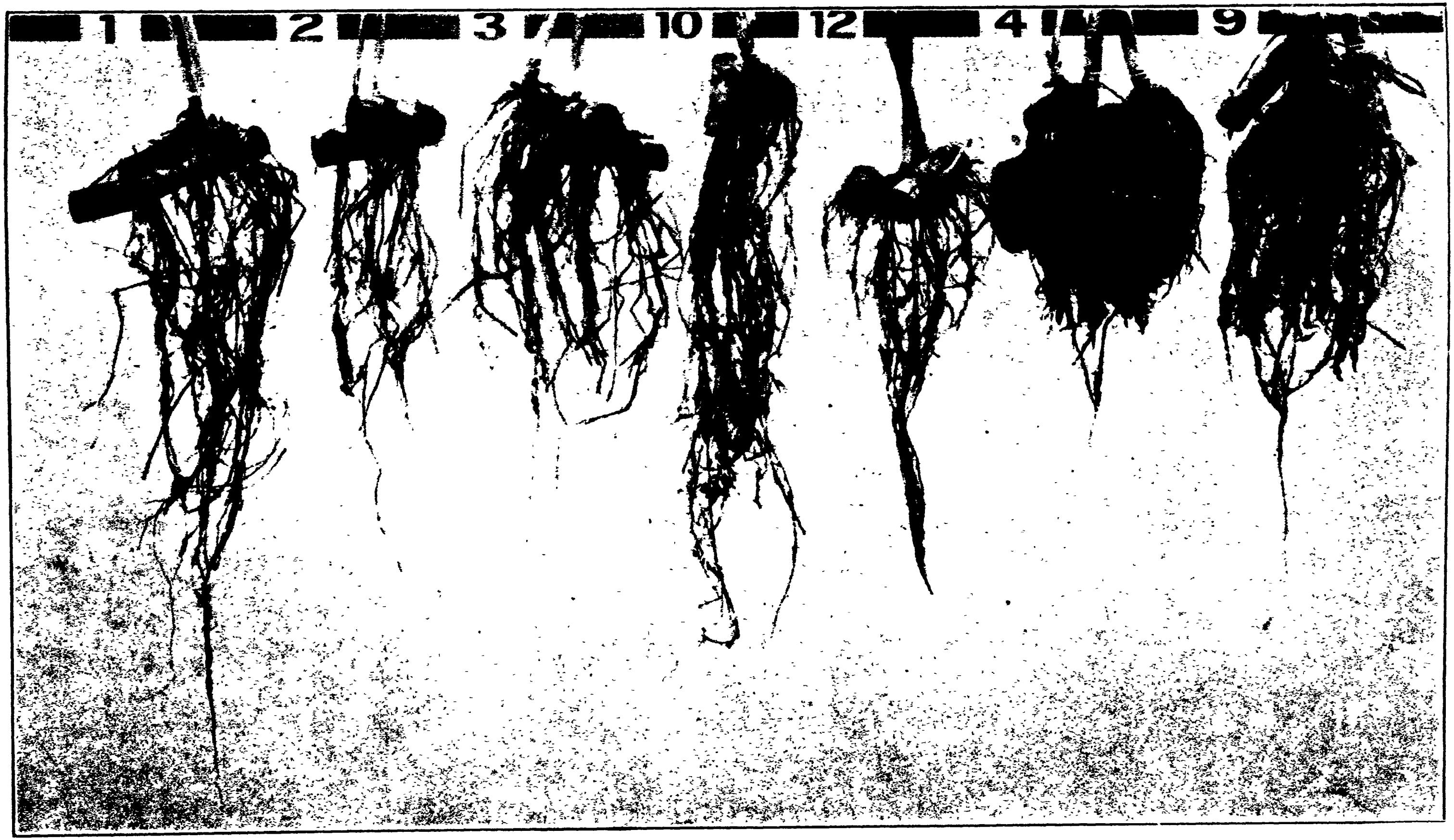

PLATE IV.

Root systems, Lahaina cane, age 4½ months. Sterilized Waipio sick soil.
Fig. 1–2–3–10–12.—Soil inoculated with *Pythium* from cane. Note ragged root system and lack of feeders.
Fig. 4–9.—Uninoculated controls. Note mass of feeders.

PLATE V.

Root systems steamed sick Waipio soil. Closer view of certain figures of Plate IV. Figs. 3, 10, 12, inoculated soil. Fig. 4, uninoculated control. Age, 4½ months. Note mass of secondary feeding roots. The fungus restricts the development of feeding roots, and cuts off the primary roots to a great or less extent.

A partial recovery of little affected plants and checked spreading of the disease in the late spring and summer months is annually remarked.[1]

With both crops, however, the first symptom is checked growth. As to the periods when the damage is done, the writer believes that these occur for the most part in the cooler months of the year: (1) When vegetative vigor is at its lowest ebb; (2) when there is more moisture present in the soil, and soil conditions, particularly temperature, are perhaps otherwise more suitable to the parasite or less favorable to the cane; (3) another critical period is possibly the time when the energies of plants turn from vegetative to reproductive activity, since in the relation of other plants to certain diseases this is a critical time.

From our present data we cannot say that the *Pythium* fungus is constantly associated with the diseases, pineapple "wilt" and Lahaina disease. It is found, however, often enough and under such conditions as to make it seem probable that such is the case.

When the fungus is found in suitable material, roots which are in an early stage of attack, it is sufficiently abundant to account for root failure, and there is ample evidence in the disposition of the mycelium, etc., that the organism is actively invading cell after cell and appropriating the cell contents for its own development. In pot cultures there remains no doubt as to the ability of the *Pythium* type fungus to occupy and destroy the roots of Lahaina cane.

Parasitism of the Pythium Type Fungus from Lahaina Cane.

Positive Inoculations of Sugar Cane.

The symptoms of root disease which appear to be a constant feature with respect to the roots themselves, are a softened and watery appearance, or total collapse of the roots from the growing tip backward, red, canker-like spots on the larger roots at almost any point, ultimately girdling and destroying the cortex of the root, and final softening and decomposition of the central root cylinder or conducting portion beneath the cankered area. The result is a scarcity of secondary or feeding roots, since, under favorable conditions, these are rotted at the end as soon as formed, and an abnormal branching of the larger or primary roots. (Pl. VI.) The tips of these dying, branches form in a cluster back of the decaying end, each root in turn dying at the end, though occasionally one root of the branch group succeeds in escaping infection for some time. These are the characters of root disease of cane one finds in the artificially induced disease in sterilized soils in pots, and also in plants diseased as a result of growing the Lahaina cane in sick soils unsterilized in pots. Similar effects are rather constantly found in field material.

Our observations of diseased Lahaina cane and pineapples from the field where we have succeeded in finding suitable material in the early stages of root trouble, lead us to believe that these are the train of symptoms manifested by the roots in the course of these diseases as they exist in the field. In such

[1] Cf. Planters' Record XII, p. 383, and Figs. 6-7. 1915.

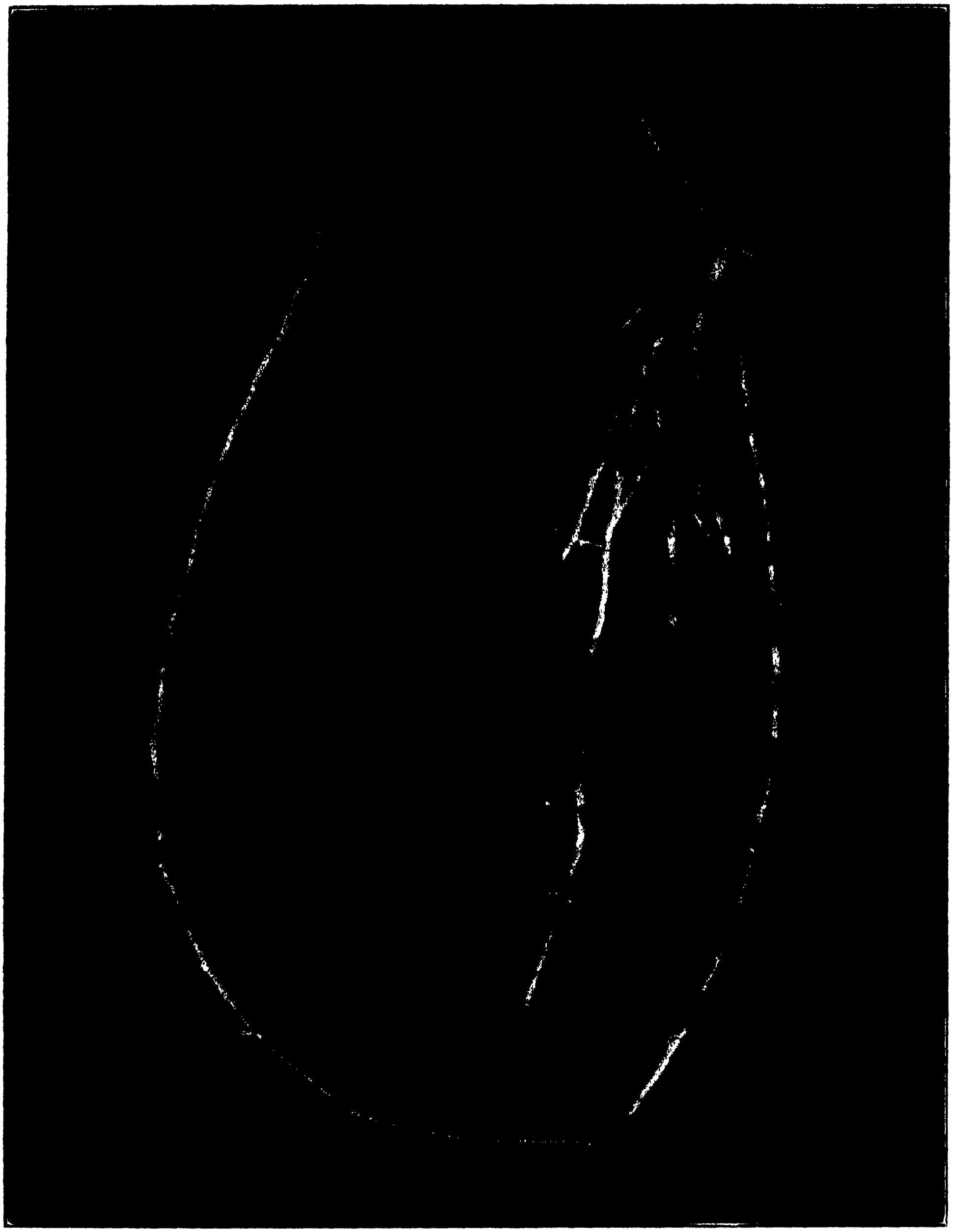

PLATE VI.

Under favorable conditions the fungus attacks the growing tip of the root, preventing further development; branch roots issue and meet the same fate. Primary roots thus checked cannot wander and forage, or develop with wide range to carry the feeders to adjacent fertile situations.

Abnormal branching. Lahaina cane root. The main root and all branches but one are rotted or softened at the growing tip.

material, as well as occasionally in pot cultures, after the roots have practically all become affected by the disease, a few new roots may come out and, curiously enough, show no signs of lesions for a considerable period. It is becoming increasingly evident that it is very important to determine the obscure factors of environment which limit the disease.

Altogether, in the writer's soil inoculation experiments with pure cultures of the *Pythium* type fungus isolated from Lahaina cane roots, some fifty Lahaina cane plants have been inoculated, and subsequent developments, compared with controls, have been watched. These cane plants have been grown in soil sterilized at from 25 to 40 pounds of live steam for one hour. After an incubation period of varying duration the entire root systems have been washed out carefully and comparisons made. (Pls. II to VII.) In no case has there been failure to induce root disease in some degree, and in most cases a very striking difference existed between total roots of inoculated plants and those of control plants identically treated except for the inoculation. In only a few cases were there any root lesions at all on the controls; where there were lesions they were not serious, and not to be definitely determined as of the *Pythium* sort. Dark colored lesions occur in old pot cultures as a result of crowding when the roots come into forcible contact with the side of the pot or struggle to get through the opening in the bottom. Such lesions, while simulating the *Pythium* cankers, are not in general to be confused with them.

In the root tips and lesions of inoculated plants the same evidences of fungus occupancy were found as in field material. The cells were permeated and occupied by fungus mycelium and haustoria-like processes, often in swollen globular form, finely granular and difficult to see at first. Resting spores of the *Pythium* type were present likewise. The latter are often crowded in large numbers in the root tips when collapse commences. (Pl. II.) They are less in evidence in old collapsed roots and it is a question what becomes of them.

To finally prove the theory, it is desirable to inoculate Lahaina cane growing in virgin soil or soil uninhabited by the *Pythium* fungus, thus demonstrating that in the field plants in inoculated soil get the Lahaina disease, while those in uninoculated soils adjacent do not suffer. The evidence of former experiments by other workers with Lahaina cane in virgin soil is such that experiments of this sort do not seem to promise conclusive results. It appears that where the disease *can* occur the conditions are already present, including the fungus, so that if susceptible plants are put in the disease will appear when meteorological and soil conditions are favorable.

We do not know whether the fungus is already widely distributed, or universally present, in our soils, and that the outbreaks of disease accompany favorable soil conditions, or whether, under the same "soil conditions," the disease occurs only as the fungus spreads from field to field.

We must establish the following point:

Does the typical disease occur in the absence of the Pythium type fungus?

It is our impression that when we see the disease, especially in the pineapple, gradually spreading over a field not hitherto observed to have the "wilt," we are merely observing the after effects, the root disease having gone over the same area, possibly months earlier, the fungus preventing the development

PLATE VII.

Showing that natural sick plants and inoculated sick plants are approximately the same size in contrast with healthy control. Later the natural sick plants become larger than the artificially sick plants, probably due to the fact that steamed soils offer a more favorable situation for soil parasites, a fact often noted in the literature.

Lahaina cane. Age 57 days.

Fig. 1.—Sick Waipio soil.

Fig. 2.—Sick Waipio soil sterilized and inoculated one month previously.

Fig. 4.—Uninoculated control, sterilized soil.

of an adequate root system until the advent of other conditions more favorable to the p'ant. The after effects proceed progressively, following the same general lines as the root disease. It would seem that the fungus is the ultimate limiting factor, rather than the meteorological and soil conditions, since we do have this evidence of spreading. In such cases as are recorded where Lahaina cane and pineapples failed in virgin soil, the parasite has probably been introduced by irrigation water, implements, etc. This is in accordance with the writer's original theory that the fungus determines the disease ultimately, but that it is only active under certain conditions, the two factors being in their interaction responsible for the capricious nature of the diseases. There are two climatological factors which may be the ones responsible for the activity of the fungus. These are rain accompanied by unusually low temperatures; in Hawaii with our equable climate, a few degrees is a usual drop in temperature in the winter months.

With respect to natural factors which bear a relation to infection, severity of disease and seemingly inexplicable recovery, recent investigations by Jones,[1] and Johnson and Hartman[2] on the relations of soil temperatures to plant diseases are significant. Jones cites many instances from various workers and with several diseases which add weight to this phase of the relation between environment and parasitism. He makes the following statement (l. c. p. 230):

> "Thus, for at least two groups of seedling or root-invading parasites, certain smuts and Fusariums, slight variations in soil temperature at critical periods seem to be the deciding factors in possible parasitism."

Johnson and Hartman made a study of the influence of soil environment on the root rot of tobacco. Although this is a different disease, a few statements from their conclusions seem to be of the utmost significance to our problem and are quoted:[3]

> "The root rot of tobacco, caused by *Thielavia basicola,* is marked by the stunting of plants in various degrees, due to a reduced root system. The extent of the damage is determined in a large manner by the environmental conditions surrounding the roots of the host.
>
> "The factors especially studied were the amount of infestation in the soil, the soil moisture, soil temperature, soil reaction, physical structure and fertility. . . . Under normal conditions the end result in injury by root rot is the sum total of the favorable and unfavorable action of these factors on the disease.
>
> "*The temperature of the soil is undoubtedly the most important factor in determining the extent of the root rot of tobacco, other factors being equal. The most favorable temperature for the disease ranges from 17° to 23° C. (62.6° to 73.40° F.). Below 15° (59° F.) the disease is less marked, and above 26° (78.8° F.) the severity is gradually reduced* until at about 29° or 30° (84.2° to 86° F.) it has little or no influence. At 32° C. (89.6° F.) practically no infection occurs even in the most heavily infested soils. Soil temperature records in the field for four seasons indicate that *the occurrence of the disease under practical conditions is determined primarily by soil temperature.*

[1] Jones, L. R.—Soil temperatures as a factor in Phytopathology. *In* Plant World, v. 20, pp. 229–237. 1917.

[2] Johnson, James, and Hartman, R. E.—*In* Journal of Agricultural Research, Vol. XVII, pp. 41–86. 1919.

[3] Fahrenheit temperatures and italics, the writer's.

PLATE VIII.

Response to copper sulfate. (Compare with Plates IX and X.)

The plant in pot 3 gained over the plant in pot 2, when watered for one month with 1-50,000 copper sulfate solution.

Copper sulphate 1-100,000 apparently had no effect in the same time, cf. Plate X.

Pot 3 received 12 applications of 750 cc. each of 1-50,000 copper sulfate during the month, i.e. approximating .18 grams of c.p. copper sulfate was applied to the soil of the 12-inch pot. Other pots, same amount of water.

Fig. 5 showed no increase in size over Fig. 4 of Plate IX, both being uninoculated controls; Fig. 4 receiving no copper sulfate, and Fig. 5 receiving the same amount as Fig. 3. *It is obvious that a controlling effect on the fungus is indicated here, and not merely a stimulating effect on the plant.*

Cf. Planters' Record, June, 1920, for response of Lahaina cane to "Qua-Sul."

Lahaina cane, age 84 days.

(Fig. 2 and 4 same as in Plate VII, one month later.)

Fig. 2.—Sterilized sick soil inoculated.

Fig. 3.—Sterilized sick soil inoculated; watered past 27 days only with 1-50,000 copper sulfate.

Fig. 5.—Sterilized soil, uninoculated control. Watered with 1-50,000 copper sulfate past 27 days.

> "Field observations and limited laboratory experiments seem to show that infested soils when compacted are more favorable for the disease than loose, open soil."

Considering these observations on the determining effect of temperature on plant diseases, there is support for the theory of a parasitic origin of Lahaina disease in the following quotation from Agee.[1]

> "There is perhaps no influence that contributes in a greater degree to the failure of Lahaina cane than the cool weather of our winter months. Time after time it has been noted that Lahaina planted in June or thereabouts will come to a good stand and grow vigorously until about October. At this point in many cases growth appears to cease entirely. The plants struggle along, putting out a few new roots to replace those which are rotting away. Finally the top may rot off if conditions reach their worst, or the second summer may, particularly if there are rains, bring about a renewed growth. Oftentimes, however, the cane does not succumb at the first cool days. Its growth is checked very gradually. Then there appears a series of abnormally short joints and later it may either resume average growth or continue stunted."

Positive Inoculations of the Pineapple.

Such inoculations of pineapple plants as have been made with the *Pythium* type fungus isolated from Lahaina cane resulted in stunting of the plants compared with uninoculated controls. (Pl. XIII.) The pineapples were grown in sterilized soil in twelve-inch pots. Other wilt symptoms, such as yellowing, narrowing and twisting of the leaves and lack of normal turgor, while not strikingly present, nevertheless were detected. Roots of inoculated plants showed characteristic inhabitation of the cells by the fungus such as has been seen in field material and such as is characteristic of the cane material, both naturally and artificially diseased.

Recently a successful isolation of a *Pythium* type fungus was made from a pineapple "wilt" plant from Kailua, Oahu. This plant was placed in water, and after a few days new roots came out among the old roots. These new roots finally collapsed and numerous spores, mycelium, etc., were detected with the microscope. A *Pythium* type fungus was then isolated. Should this prove to be a parasitic strain for the pine, a distinct step as far as "wilt" is concerned will have been made. Inoculation tests with this fungus are under way.

Reisolation of Pythium Fungus.

In a large number of cases, and in fact in practically all the attempts made, the writer has been successful in reisolating the used fungus. In the only attempt made such a reisolated strain of the fungus from artificially induced root rot again produced the disease upon inoculation of cane in sterilized soil. This type of work, soil inoculation and reisolation of the fungus from root lesions, was continued until it seemed conclusive to the writer, but some further work along such lines will be done.

[1] Planters' Record, Vol. XII, p. 383. 1915.

PLATE IX.

Response of plants to 1-50,000 copper sulfate, and lack of response to 1-100,000 copper sulfate. Cf. Plates VIII and IX, and caption Plate VIII.

Steam sterilized sick Waipio soils. Inoculated, and watered with copper sulfate.

Fig. 3.—Inoculated with *Pythium*. Watered past month with 1-50,000 copper sulfate solution.

Fig. 12.—Same as Fig. 3, but watered with 1-100,000 copper sulfate solution.

Fig. 13.—Uninoculated control, watered with 1-100,000 copper sulfate solution.

Certain additional observations indicate that the root rot of Lahaina cane and pineapples is of parasitic origin. Lahaina cane in sick soil sterilized by means of either steam or formalin developed a healthy root system in contrast to cane in unsterilized sick soils. (Pl. I.) The disease appears to spread in the fields with considerable rapidity, both in pineapples and cane. Likewise the diseases are periodic and somewhat seasonal in their occurrence. In cane some varieties, such as H 109, D 1135 and Yellow Caledonia, are markedly resistant under field conditions, though they do in restricted areas in the fields show the characteristic symptoms of the disease, together with root failure and root lesions with associated mycelium and resting spores of the *Pythium* type.

Negative Inoculations with Other Fungi.

As additional or contributory experimental evidence bearing out the *Pythium* theory the negative results of inoculations with pure cultures of other fungi may be cited.

Inoculations of Lahaina cane have been made with pure cultures of the following:

1. *Pythium debaryanum* from damping off of sugar beets. Courtesy of U. S. Dept. of Agriculture.
2. *Rheosporangium aphanodermatus* type. Isolated from roots of Lahaina cane. At first considered identical with the writer's *Pythium* strains. Culture studies resulted in the development of presporangia and zoospores.
3. *Fusarium*. Of this genus, from a large number of cultures, two species which belong to parasitic types were selected for tests. One, No. 295 A., resembles *Fusarium herbarum* (Corda) Fries, related to or synonymous with *F. pirinum* and *F. putrefaciens*. The other, No. 314 F., is an *Elegans* type, suggesting *Fusarium oxysporum* (Schlecht.) Smith.
4. *Meliola* or *Capnodium*. The *Capnodium*, or sooty mold fungus, which is a conspicuous superficial occupant of canes; when dry it gives a smoky color to the cane.
5. *Rhizoctonia* sp. A species of *Rhizoctonia*, No. 23 A., was isolated from the roots of affected cane; its counterpart, with regularly constricted mycelium, is often seen occupying the surface cells of roots of diseased cane plants.

The above fungi, *Pythium* from sugar beet, and *Rheosporangium, Capnodium, Fusarium*, and *Rhizoctonia* sp. from cane, all failed to produce symptoms of root disease, and no lesions could be found which indicate that they are parasitic in any significant degree. (Pls. XI, XII.) In parallel comparative soil inoculations with the parasitic *Pythium* from cane, positive results were strikingly obtained. (Pls. III, VII.) All tests were made by inoculation of the steam sterilized soil.

The Pythium Type Fungus.

The life history of the *Pythium* found parasitic on Lahaina cane in pots is not yet worked out. There are points in its morphology necessary to determine before the fungus can be satisfactorily classified. Therefore, it is best called the *Pythium* type fungus for the present. If it forms zoospores, free

PLATE X.
(Compare Plate VIII.)

Lahaina cane; age 84 days.

(Fig. 2, same as Plate VII and Plate VIII. Fig 3, same as in Plate VIII.)

Fig. 2.—Sterilized sick soil inoculated with *Pythium*.

Fig. 3.—Sterilized sick soil inoculated with *Pythium*. Watered past 27 days only with 1–50,000 copper sulfate.

Fig. 4.—Sterilized soil, uninoculated, untreated.

swimming asexual spores, their mode of formation and liberation will indicate to what genus the fungus belongs. No zoospores have been found in pure cultures, though such spores have been seen in diseased material; whether they belonged to this *Pythium* type fungus or to some related saprophytic fungus could not be determined. A description of the fungus will not be attempted until further morphological studies have been made. The illustrations in the writer's preliminary report show some significant features of the fungus with which we are concerned.

The Genus Pythium.

The genus *Pythium* is a small group of primitive fungi, sometimes included with the Saprolegniaceae and sometimes with the Peronosporaceae. The genus is best known by the representative plant pest *Pythium debaryanum*, a common seedling parasite, cause of "damping off." The group includes both aquatic and terrestrial forms. The absence of chlorophyll is the main distinguishing point between these primitive fungi and some of the algae.

The usual point of attack in the "damping off" disease of seedlings is at or near the surface of the ground. The effects are evident a few days after the seedlings come up, the tender tissues, being occupied by the mycelium of the fungus, lose their turgidity and the plant topples over. While *P. debaryanum* is most common as a greenhouse pest, "damping off" also occurs in the field. Among other plants attacked by *P. debaryanum* are corn and other members of the grass family. *P. Butleri*[1] is recently described in India as a parasite on papaya (foot rot), tobacco (damping off) and ginger (rhizome and foot rot). The *Pythiae* appear to occupy the soil as frequently as they do water, and are in exceptional cases found causing diseases of the aerial portion of plants (*P. palmivorum* Butler, said to cause top rot of palms).

Besides the delicate mycelium, the *Pythiae* form asexual swimming spores and sexual resting spores. Sporangia empty their contents as free swimming zoospores, or germinate directly, in which case they are called conidia. Some of the terrestrial species appear to have lost the power of zoospore formation. They are not readily detected in *P. debaryanum*, in pure culture, and thus far the writer has failed to detect them in pure cultures of the cane fungus. Until the method of zoospore formation is determined, if such are formed at all, this fungus cannot be satisfactorily placed in its proper genus. The sexual spores, or oospores, are thick-walled spherical spores, adapted to carry the fungus through adverse conditions. Such oospores formed in pure cultures of the fungus from cane, agree closely in size with the similar spores in the roots of diseased cane and pineapple, and correspond to published measurements of species of *Pythium*.

PART III—THE PROBLEM OF CONTROL.

If Lahaina root failure and pineapple "wilt" are caused by a fungus of the *Pythium* type, we should ultimately be able to find a practicable means of controlling these diseases. First it is desirable that growers cooperate in furnishing us as complete records as possible on the occurrence of the disease, seasonal his-

[1] Subramaniam, L. S.—*In* Memoirs Dept. Agric. India, Vol. X, pp. 181-194. 1919.

PLATE XI.

Negative inoculations with *Rheosporangium aphanodermatus* type fungus from cane. Steam sterilized soil.

R. aphanodermatus occurs on sugar beets. This type of fungus is readily mistaken for *Pythium* sp. unless zoospores are detected. The fungus here used was isolated from Lahaina cane roots at Waipio, and was mistaken at first for the *Pythium* type fungus. No evidence of parasitism was found.

Fig. 15, 6.—Soil inoculated with *R. aphanodermatus* type fungus.

Fig. 7.—Uninoculated control.

PLATE XII.

Negative inoculations with sugar beet *Pythium*.
Steam sterilized soil. Age 3 months.
Fig. 9–18.—Inoculated with *Pythium* from sugar beet.
Fig. 14.—Uninoculated control.

tory, weather conditions, etc. Against these records the writer's present impressions, which are given below, can be checked so that control experiments may take due account of the relation of weather conditions to the inception and duration of disease.

It seems to be agreed that the symptoms of pineapple "wilt" are most alarmingly prevalent in the spring months. Similarly the Lahaina root disease, or crop failure, is most strikingly prevalent in the autumn and winter months. It appears possible to the writer that both diseases begin simultaneously, but in the cane the effect of a crippled root system is sooner apparent in checked and abnormal growth, while in the pineapple several months during the wetter part of the year are required to show alarming above-ground symptoms. Both crops in our experience recover in some degree by June and subsequently. In cane the joints lengthen out, and in the pineapple, plants not too far gone freshen up, and the spreading of the disease is checked.

If this impression as to the seasonal character of the diseases is correct, chemical and other control treatments should be concentrated in the period from September or October through the cool weather, rather than applied hit or miss at the time experiments are put in, when likely as not the chemicals are all used up or are relatively inactive elements when most needed.

The writer's note on a possible control of the root rot of the two crops by chemical means, in the June Record, 1920, indicates that it may be practicable under field conditions to apply to the soil in the irrigation water sufficient of a specific chemical to check the parasite without being toxic to the host plant. (Pls. VIII, IX, X.) The range between the two effects will probably be small, but experiments along this line are being continued.

With cane, the resistant variety H 109 is gradually supplanting Lahaina, but since this variety, as well as others, takes the root disease in some degree it is desirable that we solve the root rot problem. It is likewise desirable since varieties which are standard for a period of years are said to degenerate. If degeneration is the same in other varieties as in Lahaina, a natural or acquired susceptibility to root rot, it will be very advantageous to know the exact conditions which a variety finally becomes unable to endure.

Should applications of chemicals to the soil be proved desirable in combating the root disease of pineapples, they can be sprinkled on the soil in advance of the cool, rainy season in solution, and theoretically at the time needed will be carried down about the roots by the rain. Whether rain favors the disease or the reverse is not known, and with this, as with numerous other features of the obscure problem, we have contradictory evidence.

As stated elsewhere, the criterion of a successful treatment is gain in yield of treated affected areas over untreated affected areas. Improvement as a result of treatment, where adequately checked by control plots, is encouraging, but with a problem of this sort, in order that such improvement may not be confused with seasonal improvement and erratic occurrence of the disease, considerable time must elapse before any treatment can be said to be successful. The treatment must be more than a stimulant which encourages root development for a short time; it must in some degree prevent the plant losing its roots in the first place. Secondary roots die off anyway after a time, but the writer

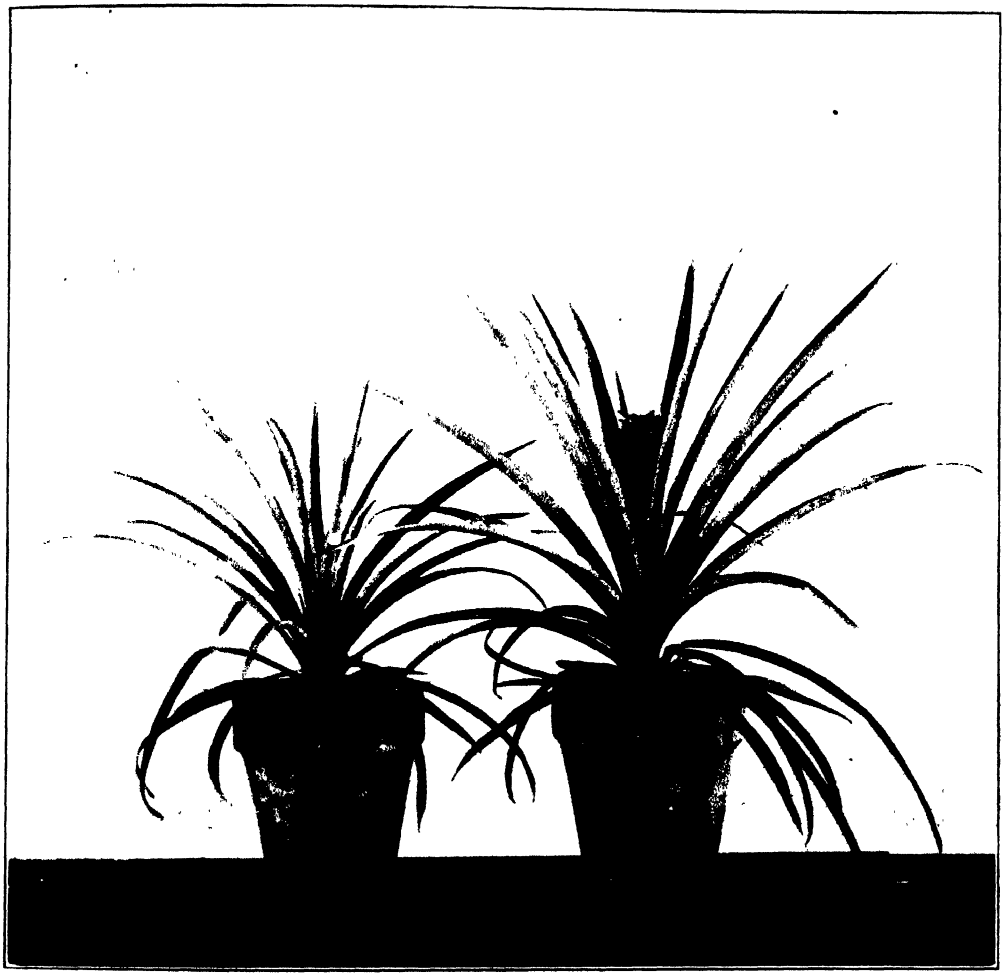

PLATE XIII.

Pineapple plants and the *Pythium* from cane.
Steam sterilized soil. Plants 11 months old.
At left, soil inoculated 1 month after planting with *Pythium* type fungus from cane.
At right, uninoculated control.

is persuaded by the evidence that both crops under discussion lose both primary and secondary roots altogether too rapidly at times for this to be a normal occurrence. The effect of the disease is so profound to a fundamental part of the plant that a successful treatment in my judgment must be preventive rather than curative.

PRESENT STATUS OF THE PROBLEM IN BRIEF.

1. Lahaina disease and pineapple wilt are essentially of the same origin and are the result of damping off of the roots.
2. The resistant varieties, Yellow Caledonia, Demerara 1135 and Hawaii 109, take the disease in some degree. Apparently the resistance is relative, not absolute.
3. The "damping off" or rotting of the roots is caused by a specific fungus of the *Pythium* type.
4. The fungus is active only periodically and under certain environmental conditions.
5. From our observations, and the literature of other diseases, by analogy, the controlling factor in the activity of the fungus is soil temperature. The period of active damage to the root systems appears to be limited in general to the cooler months, i.e., October to April. Soil reaction is also a factor of some importance.
6. Chemical applications to the soil and other measures for control should be applied for action in the corresponding period.
7. The treatment must be largely preventive, owing to the profound results of loss of the root system. So far as the individual root is concerned the treatment must entirely prevent softening of the growing tip, since with a dead tip growth cannot be resumed.
8. Pot experiments indicate that we shall be able to control these diseases by chemical applications to the soils.
9. The promising chemicals thus far tried are "Qua-Sul"[1] lime-sulphur and copper sulphate 1/50,000, in the order named.
10. Resting spores of the *Pythium* type have been found in the roots of cane on the Islands of Oahu, Kauai, Maui and Hawaii.
11. Resting spores of the same general type have been found associated with their appropriate mycelium in the roots of Chinese banana, taro, and rice. In the banana the spores suggest a *Phytophthora* rather than a *Pythium*.

[1] A soluble sulphur-carbon-soda patented preparation. (Cf. Pl. Rec., June, 1920, p. 350.)

Horizontal Tubular Boiler Settings and Details of Installation.*

By H. E. Dart.[1]

Our Engineering Department is now engaged in making new drawings of setting plans for horizontal tubular boilers. In past years there has been a big demand for such setting plans and some of the tracings for the more common sizes of boilers are literally worn out. In making the new drawings, advantage is taken of the opportunity to show certain features in greater detail than was formerly the case and the scope of the plans has also been extended so as to include typical methods of piping and the proper manner for installing the usual fittings and attachments. Figures are also given to show the quantities of bricks required for setting the boilers in accordance with the plans. For each of the common sizes of boilers, it is the intention to make four drawings, two with overhanging fronts and two with flush fronts, one of each style showing boilers suspended independently of the setting walls and the other showing boilers supported by means of brackets resting on the walls. The complete set of plans is not yet finished, but drawings are ready for many of the ordinary sizes of boilers and blueprints can be furnished from such drawings as are finished. Requests for such blueprints should be made preferably through the chief inspector of the department in which the boilers are located (see list of departments on back of The Locomotive) rather than directly to the Engineering Department, because our chief inspectors are familiar with the conditions which exist and are generally able to submit the data which we need to determine which drawing is best adapted to each particular case.

The most important features in connection with the new setting plans are described below. While many of the features mentioned will apply equally well to the design of settings for any other type of boiler, it should be remembered that this description is concerned primarily with hand-fired horizontal tubular boilers using coal for fuel, and is written from that viewpoint.

Wall Construction.

On our old setting plans the outside walls are shown as indicated by Type I, Figure A, but on the new plans we are showing all of the four types of construction described in Figure A, leaving it to the boiler owner to make his choice between these designs. Complete dimensions are given on the drawings for each type of construction.

The design shown by Type I involves the construction of two separate brick walls, bonded solidly together for a distance of about sixteen inches at the top and at the bottom, but separated by an air space two inches wide for the remainder of the height. It is thought by many people that this air space acts as a heat insulator, but such is not the case; experiments by the Bureau of Mines

* The Locomotive. The Hartford Steam Boiler and Insurance Co, April, 1920.

[1] Superintendent of Engineering Department; The Hartford Steam Boi er Inspection and Insurance Co.

have shown that a wall of this type will transmit just as much heat under given conditions as a solid wall of the same total thickness. As regards air leakage into the furnace, however, the double wall with air space has a distinct advantage over the solid wall shown by Type II because the cracks will occur principally in the inner wall, leaving the outer wall intact. With a solid wall, the cracks will extend clear through the brickwork, thus greatly increasing the probability of air leaks and thereby decreasing the efficiency on account of excess air. Not long ago we had occasion to make an examination of a solid-

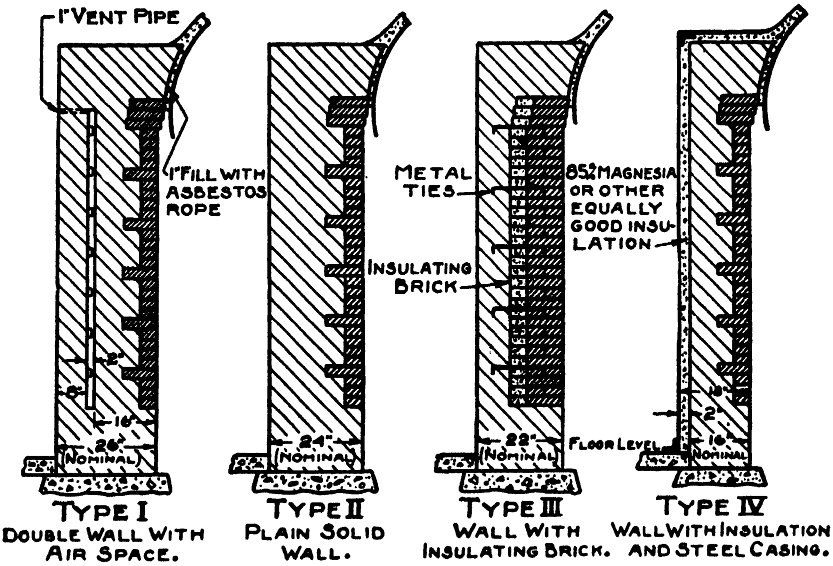

Fig. A.—Different Types of Construction for Setting Walls

wall setting which had been built in the same boiler room with two older settings of the air space type. Although the new setting had been in use only a few months the test with a candle flame showed more leaks than were found in the other settings which had been used several years. Of course such a test is not entirely conclusive, since there are other features which should be considered, but we believe it gives a fair indication as to what may be expected in the average case. In constructing setting walls with an air space it is advisable to insert a few ventpipes as indicated in the cut, these pipes being especially desirable if the bricks contain much moisture when they are laid. After the setting has thoroughly dried out, all ventpipes should be permanently sealed so as to prevent air leakage into the setting and heat radiation from the inner wall.

Type III in Figure A makes use of insulating bricks to reduce the amount of heat that is transmitted through the wall and thereby lost. These insulating bricks are made of different materials by different manufacturers and they are cut to the proper size to lay up evenly with ordinary bricks and fire bricks. They have little mechanical strength in themselves, so that it is best to use metal ties, as shown in the cut, for bonding the inner firebrick section to the common brick on the outside. It is also advisable to use a uniform thickness of nine inches

for the firebrick lining in place of the 4½ inch lining with headers as shown for the other types. This type of construction makes a very good setting, costing somewhat more than either Type I or Type II.

Type IV is similar to Type I with a steel casing substituted for the outer wall and the air space filled with magnesia or other good insulating material. This makes a most excellent form of setting, the only drawback to its more general use being its greater cost as compared with other types. The insulating material reduces the heat radiation loss to a minimum and the steel casing prevents the even greater loss due to air leakage through the setting walls. Furthermore, a setting of this kind presents a very neat appearance and requires less space than any of the other types illustrated, there being a saving of eight inches in length and sixteen inches in width as compared with Type I. Number 8 U. S. gage steel plates should be used for the casing with angle irons placed about 3½ feet apart along the sides and back and with similar angles at the top, bottom, corners and elsewhere as needed for stiffness and stability.

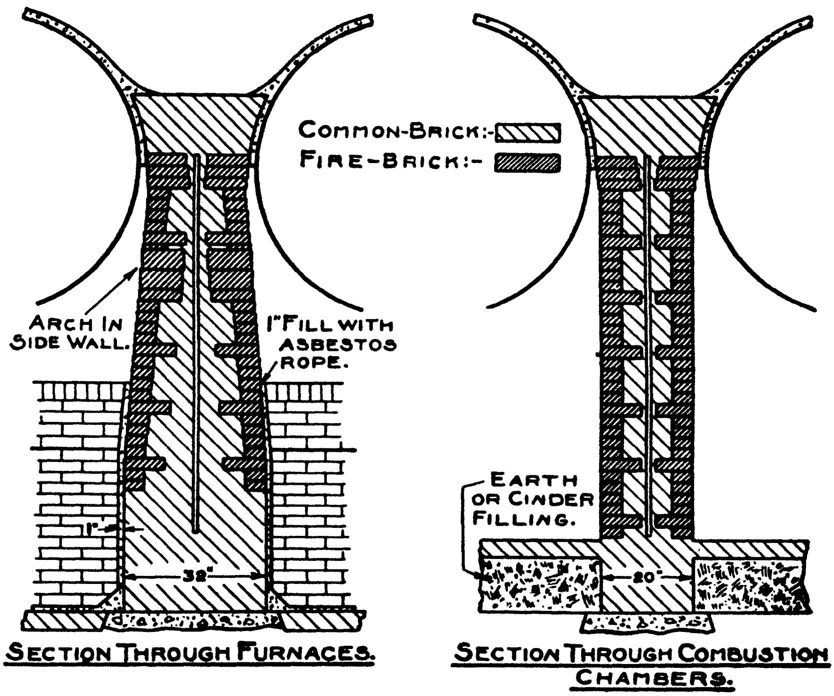

Fig. B.- -Division Walls Between Boilers Set in Battery

For the division walls between boilers set in battery the style of construction shown in Figure B is satisfactory, regardless of what type of construction is used for the outside walls. The vertical slot shown in the center of the wall does not indicate an air space like that in Type I, but is intended to show that the two walls should be built separately and not bonded together in the center. This is advisable to make allowance for expansion when there is a fire on only one side of the wall.

The sections in Figure A apply to the side walls at the rear of the bridge wall. For the furnace section in front of the bridge wall, we advise that the

walls be battered from the grate level to the closing-in line near the middle of the boiler shell. Our drawings show a batter of six inches in this height, thus making the walls that much thicker at the bottom. A reference to Figure B will make this point clear. The section at the left shows the battered wall while that at the right shows the straight form which can be used back of the bridge wall. This figure shows sections for the division wall between boilers, but the same idea should be applied to the outside walls.

In constructing side walls and division walls it is a good idea to build an arch in the firebrick lining at a height of about three feet above the grates, as illustrated in Figure C. When it is necessary to replace firebrick this arch supports the brickwork above and prevents it from falling down.

For construction like that shown in Types I, II, and IV, where the firebrick lining is only 4½ inches thick, headers should be used for every fifth course or even more frequently. In all firebrick work the joints between the bricks should be made just as thin as possible. For this reason a trowel should not be used, but the bricks should be dipped in thin fire-clay and then rubbed down into place so as to make "brick-to-brick" joints.

Allowance for Expansion and Prevention of Air Leaks.

Ample provisions should be made throughout to allow the boiler and the setting to expand without cracking the brickwork or opening up places where air can leak into the setting. If the brickwork is built tight up to the boiler shell at the closing-in line, cracks are sure to develop when the boiler is heated up and there will also be an opportunity for air to leak in between the boiler and the brickwork. It is best, therefore, to leave the brickwork about an inch away from the boiler and fill this space with asbestos rope or some similar material, as illustrated in the different sections of Figure A. In a similar way, the brickwork and the ironwork of the boiler front should be kept about ¾ inch away from the boiler shell (and concentric therewith) and this space should be filled in with asbestos rope. To prevent cracking due to endwise expansion of the bridge wall, it should be built separately from the side walls, leaving a space of about one inch at each end. This space should be filled with asbestos rope to prevent the accumulation of ashes which would become solid and nullify the advantage to be gained by building the bridge wall independently of the side walls.

At the rear end of the boiler, a space of about 1½ inches should be left between the boiler head and the brickwork; this space can best be sealed against air leakage by extending the insulating covering down over it as shown in Figure C. There is a tendency for the covering to crack open at this point as the boiler expands and contracts, but this difficulty can be largely overcome by the use of a piece of sheet iron, formed to fit over the rear end of the boiler shell and bent down over the head to extend out on top of the brickwork. With the piece of sheet iron in place under the covering the probability of cracking is lessened and, if a crack does develop, the sheet iron will tend to prevent air from leaking into the setting. We advise the use of insulating covering for the boiler top instead of the brick arches which are sometimes used. The covering is a better heat insulator and it can be removed and replaced more readily in case repairs

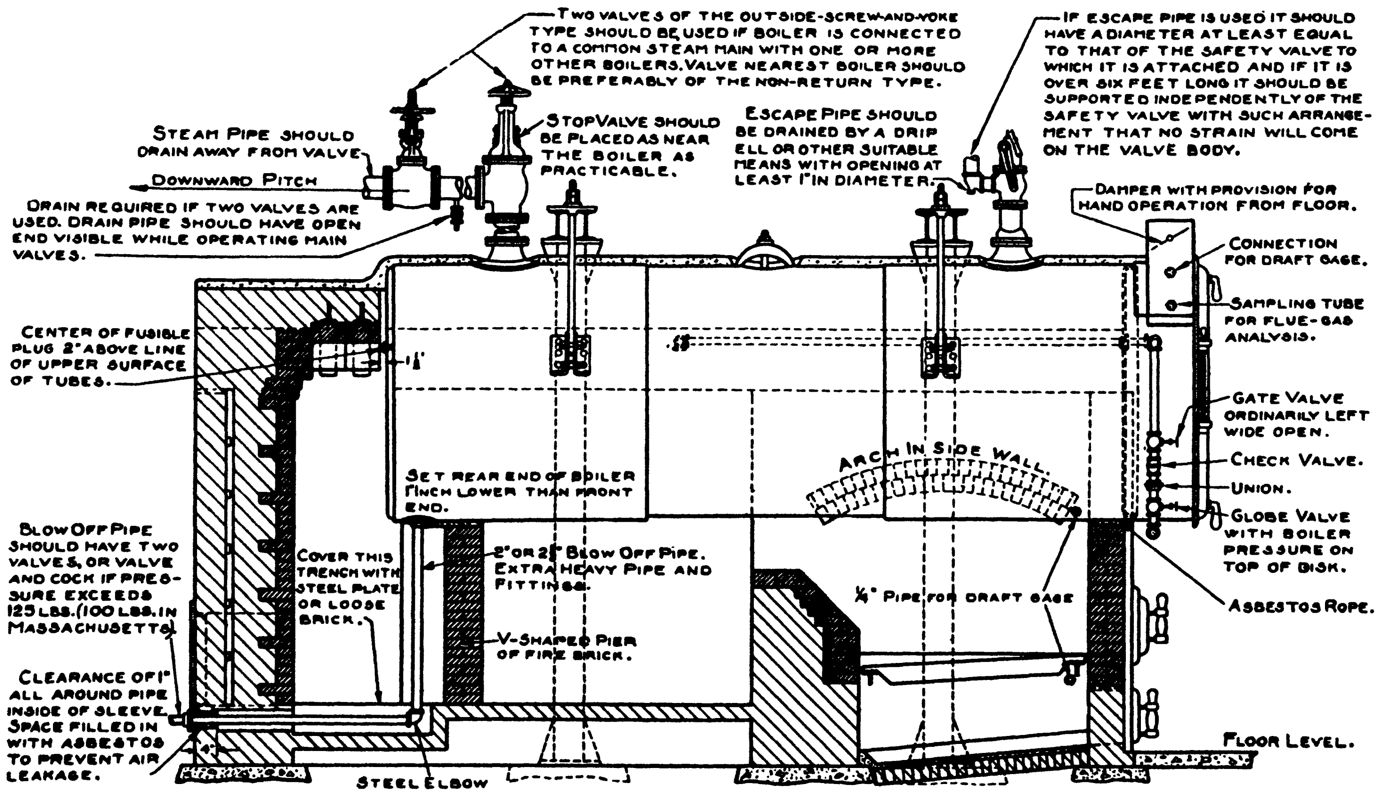

Fig. C.—Longitudinal Section Through Center of Setting.

or inspections of the boiler shell are required. The covering can best be applied in the form of blocks which can be held in position with mesh wire and then finished with plastic magnesia or other insulating cement to make a smooth finish and fill the joints between the blocks. A harder surface can be secured by using a little Portland cement in the final coat. The total thickness of the insulation should be at least two inches.

The loss due to excess air is generally greater than that from any other cause in hand-fired boilers of the type under consideration, and it is also the most difficult to prevent because it is such an intangible sort of thing that the firemen cannot be made to realize its importance. Much of this excess air leaks in through the setting walls and efforts to prevent such leakage by the methods outlined above will be well repaid. It is not sufficient merely to construct the setting as described, however; inspections and tests should be made at frequent intervals to be sure that the asbestos remains in place and that the joints are properly sealed at all points. We have made a number of investigations of this kind and we almost invariably discover air-leaks at some of the places mentioned above as well as around blow-off pipes, firing doors, clean-out doors, etc.

There are several different paints and coatings on the market which can be used to good advantage in the prevention of air leaks. Such compounds are usually composed of asphalt, asbestos and other materials, combined to produce a thick, elastic coating which will stretch without cracking as the setting expands when it is heated up. The coating is usually applied to the entire surface of the setting, care being taken to work it into all cracks, joints and openings around door-frames, boiler fronts, or other similar places. A very satisfactory home-made substitute can be prepared to take the place of the commercial compounds.

Protection of Blow-off Pipes.

The proper protection of the blow-off pipe is an important feature in connection with any setting for a horizontal tubular boiler. There are many ways of providing such protection and in making a choice between different methods one important principle to be kept in mind is that the pipe should be easily accessible for inspection. For this reason a simple pipe sleeve around the blow-off pipe is not satisfactory because such a sleeve cannot be removed without disconnecting the blow-off pipe. Split sleeves of cast-iron are better, but it is usually rather difficult to remove them after the connecting bolts have been exposed to the heat and flames. Several patented styles of blow-off covering are available and these give good results as a rule. In general, such blow-off coverings are made of some refractory material and applied in sections with an interlocking arrangement so that they are easily removable.

Except under extraordinary conditions, the method of installation shown in Figure C provides ample protection for blow-off pipes. The principal features of this method are a V-shaped pier of firebrick which prevents the flames from impinging upon the vertical portion of the pipe, and the location of the elbow in a covered trench where it will be well protected. Blow-off pipes are more liable to fail at the elbow than at any other point and the location of the

elbow in this position is therefore highly desirable. The best arrangement is to build the bottom of the combustion chamber at a somewhat higher level than the boiler-room floor so that there will be space enough to install the blow-off valve or cock without cutting into the floor. It is advisable also to locate the cleaning door at one side of the center, where there will be no interference with the blow-off valve when the door is opened. Plenty of space to permit freedom of movement, due to expansion or settlement, should be left around the pipe where it passes through the setting wall. For this purpose a pipe sleeve about four inches long should be built into the brickwork at the outer end, but a larger opening can be left around the pipe through the remainder of the wall thickness, without any sleeve. The sleeve should have a diameter 2 inches greater than that of the blow-off pipe and it should be filled with asbestos to prevent air leakage. A set-screwed collar on the pipe makes a good finish against the brickwork together with provision for a gasket of sheet asbestos or other suitable material to more thoroughly seal the opening against air leakage. The V-wall should be left a little below the boiler shell to allow for expansion and settlement, and the space should be filled with asbestos to keep the flames from impinging upon the flange where the pipe is connected to the boiler. Blow-off valves should always be located so that there will be ample opportunity for a man to get away in case of a break in the blow-off piping while he is operating the valves.

Arch bars.

The rear arch-bars shown on our setting plans and in Figure C are of the so-called "Hartford" type, designed by this Company several years ago. Bars of this type extend transversely of the setting, spanning its width and bearing upon the side walls. Except for large boilers, only two of these arch-bars are needed for a single setting, but a different pattern is required for each size of boiler. In some sections of the country the "quadrant" type of arch-bar is more popular and it is just as acceptable; this style of arch-bar is made in the form of a quadrant or ninety-degree arc of a circle. The bars rest on the rear wall, arching over to the rear head, and some means must be provided to support the upper ends, so as to permit the boiler to expand without developing air leaks. Several of these bars are needed for a single setting, the exact number depending upon the diameter of the boiler, but the same pattern can be used for all sizes of boilers where the distance from the rear head to the rear wall of the setting is the same. Both types of arch-bar described above are so designed that the metal is protected by the firebrick and not exposed to the action of the flames and hot gases; this feature should be a requirement in the design of any arch-bar.

Arch-bars should be set so as to leave a full, free opening through all the tubes, with proper provisions for inspecting and removing the fusible plug, but at the same time, care should be taken that no part of the head above the lowest permissible water level is exposed to the heat. We recently heard of a case where a head was burned, due either to poorly designed arch-bars or to placing the arch-bars so high as to expose the upper part of the head to extreme heat.

Grates.

We believe that there is a general tendency to use larger grates than necessary with hand-fired boilers of the horizontal tubular type, and this belief is borne out by our experience in several cases where we have found that coal was being burned at a rate of ten to twelve pounds per square foot of grate area per hour, whereas better results would be obtained with a rate of fifteen to twenty pounds of coal per square foot per hour. In some cases we have advised blanking off the rear part of the grates by covering them with firebrick, and a gain in economy of coal consumption has been secured in such cases. Furthermore, it has been common practice to use the same size of grates for a given diameter of boiler, regardless of the tube length, though it is obvious that if a certain area is proper for a boiler eighteen feet long it would not be correct for a sixteen-foot boiler in which the heating surface would be about 11 per cent less. Assuming an evaporation of about 9 pounds of water per pound of coal, the ratio of heating surface to grate area should be about 40 to 1 in order to develop the full rated capacity of a boiler when burning coal at the rate of fifteen pounds per square foot of grate per hour. In designing our new setting pans we have used this ratio to determine the grate area, within the limits imposed by commercial standards as regards length of grates. Provision for overloads and allowance for a lower rate of evaporation can be taken care of by burning the coal at as high a rate as twenty pounds per square foot of grate per hour, this rate being attainable with proper draft and good firing methods. On the other hand, many horizontal tubular boilers in small plants are never operated at their full capacity, and in such cases the grate area could be even smaller. It is fully realized that a larger grate area may be desirable in certain special cases, but it is believed that the ratio of 40 to 1 will give good results for the average case and, of course, this is all that a set of general plans can be expected to cover; special cases should be considered in the light of all the data available in each instance.

With battered furnace walls, as described in the foregoing, the width of grates will be six inches less than the boiler diameter, while with straight walls, as frequently used, the grates have a width equal to the diameter of the boiler. As explained above, the grate area is generally larger than it should be and the smaller dimension for width is therefore generally satisfactory. For the sake of simplicity and uniformity, stationary grates are shown on all of our setting plans, but we recommend the use of shaking grates under ordinary conditions.

Height Above Grates.

Remarkable savings in fuel consumption have been claimed in many cases as a result of setting horizontal tubular boilers at extreme heights above the grates, but, as a general rule, these claims do not seem to be fully substantiated, because all of the credit for any increased efficiency is laid to the greater height of furnace, whereas there are usually other factors which should also receive consideration. In a typical case of this kind, a new boiler is installed in a plant where there are one or more older boilers, and perhaps the new boiler is set at a height of 5 feet above the grates while the corresponding height of the old

boilers is only 28 inches. More or less careful tests are made and it is found that the new boiler is more economical in coal consumption than the old ones. It is then almost invariably assumed that the gain in economy is entirely due to setting the boiler at a greater height above the grates; although the old settings may be twelve or fifteen years old and full of cracks and openings which permit the entrance of a large percentage of excess air, while the new setting is tight, this fact is completely disregarded. Furthermore, it seems to be generally assumed that the height chosen in any such case is the proper height to give the best results, although there is usually no information available to prove that just as good results would not have been obtained with a height of 3½ feet, for instance, instead of 5 feet. In attributing a gain in economy to higher settings there are other factors also which may be ignored, such as a change in the fuel used, an improvement in the proportions or design of the new boiler as compared with the older ones, better firing methods, improved draft conditions and method of draft control, a better type of grates, etc.

For any set of fixed conditions as regards size of boiler, character of fuel and other details, it is evident that there must be some limit in height of furnace beyond which there will be no gain in economy. It would probably not be possible to fix such a limit very definitely, but much interesting information could be obtained from a series of carefully conducted tests carried out by some agency such as the Bureau of Mines, which would have the necessary apparatus and technical skill, together with the means for insuring that all other conditions remain constant while the height of the furnace is varied.

The combustion volume, and therefore the height from grates to boiler shell, should be varied in accordance with the character of the fuel used, more volume being required for fuels containing a large proportion of volatile matter than for those which contain a relatively greater percentage of fixed carbon. On our setting plans we do not show any fixed dimension for the furnace height, but we recommend certain dimensions as determined from our experience and best judgment. For a 72-inch boiler with tubes 18 feet long, for instance, the heights which we advise would be as follows:

For anthracite coal and semi-bituminous coals containing less than 18 per cent of volatile matter (Pocahontas, Georges Creek, etc.)—36 inches.

For bituminous coals containing from 18 per cent to 35 per cent of volatile matter (Pittsburgh)—40 inches.

For bituminous coals containing more than 35 per cent of volatile matter (Illinois, etc.)—44 inches.

For other sizes of boilers the figures are varied so as to maintain approximately the same ratio of combustion volume to grate area. In this connection it might be mentioned that the ratio of combustion volume to grate area would be nearly 19 to 1 for a 72-inch boiler with 18-foot tubes, set as shown in Figure C and with a height of 44 inches from grates to boiler shell. Although the setting is designed only for hand-fired horizontal tubular boilers, this ratio is considerably in excess of that ordinarly used for stoker-fired water tube boilers, which may be forced to 100 per cent or more above their nominal rating. It would therefore seem that these combustion volumes ought to be more than ample and that no gain in economy should be expected from an increase in the ratio.

Method of Support.

When boilers are suspended in battery it is best to place the supporting columns entirely outside of the setting walls, using only four columns with beams of sufficient strength to support the boilers in a single span. With standard I-beams it is possible to support in this manner three boilers of any diameter not exceeding 78 inches or two boilers of larger diameter. If the installation involves more boilers it is best to set them in separate batteries of two or three boilers each, rather than to use columns in the division walls between boilers; if it is absolutely necessary to use such intermediate columns, an air space should be left all around each one with a suitable ventilating duct to admit air at the bottom. We know of several cases where columns have been burned off or otherwise damaged when built solidly into setting walls.

Our setting plans show the proper sizes of I-beams to use for suspending boilers, together with alternate designs for both round and square cast-iron columns, structural steel H-beams and built-up columns made of plates and angles. In general it will be found that these designs are heavier than those usually employed by boiler manufacturers, but we think that these sizes are needed in order for the columns to have a strength equal to that of all other parts of the installation where it is customary to use a factor of safety of 5. Boiler columns are loaded entirely at one side and the stresses are therefore greater than when the loading is symmetrical as assumed in the tables published in structural steel handbooks. Furthermore, proper consideration should always be given to the "ratio of slenderness," a heavier section being needed for a long column than for a shorter one carrying the same load. I-beams are frequently used for columns, but they are not well adapted for the purpose as the distribution of metal in the I-beam section does not make a good column design. Our Engineering Department can furnish designs for reinforced concrete columns if desired.

Boilers having a diameter of 78 inches or less can be supported by brackets which rest upon bearing plates built into the setting walls, but the suspension method is better, particularly for the larger sizes. Four brackets (two on each side) are sufficient for boiler diameters of 54 inches or less, but eight brackets should be used for boilers larger than this size; the brackets should be located in pairs with a single bearing plate for each pair. Brackets at the front end should rest directly upon the plates, but rollers should be used under the brackets at the rear end to permit free expansion of the boiler. As a rule, not enough care is used in setting the bearing plates, with the result that a good bearing is not obtained over the entire surface of both brackets. In an extreme case the bearing may be only along one edge of one bracket. The boiler should be supported by blocking or other suitable means while the setting is being built and its weight should not be allowed to come upon the walls until the mortar has thoroughly hardened so that there will be no settling.

Installation of Boiler Piping, Valves, Fittings, etc.

Figure C shows a typical longitudinal section through a suspended boiler with overhanging front. Several self-explanatory notes will be found on this

drawing relative to the proper installation of piping, valves and other details. In addition to the items mentioned the following details should receive attention in any well planned installation.

The steam gage should be graduated at least 50 per cent in excess of the maximum allowable working pressure and it should be piped up with a siphon, union cock, drip cock, and connection with stop valve for test gage, brass pipe and fittings being used throughout.

A water glass and three gage cocks should be used. The lowest visible part of the water glass should be at least two inches above the center of the fusible plug and the gage cocks should be located within the range of the visible length of the glass. Brass pipe and fittings, 1¼ inch size, should be used for the water connection to the water column except for small boilers where the minimum size may be 1 inch. To facilitate cleaning, plugged crosses should be used in these water connections in lieu of tees or elbows.

A blow-down pipe should be provided for the water column with a gate-valve or cock. This pipe should have a diameter of at least ¾ inch and should be connected to the ash pit or some other safe and convenient point of waste. It should be secured to the boiler front near the bottom by a pipe-clip or other suitable means.

All valves and fittings should be of extra heavy pattern if the pressure exceeds 125 pounds per square inch. In Massachusetts a State law fixes this limit at 100 pounds.

A sampling pipe for flue gas analysis and three ¼ inch pipes for draft gage connections should be placed in position when the setting is being built, even though it is not expected to use them. The expense is insignificant and they may prove useful.

The foregoing description is intended to cover the more important features connected with the construction of brick settings for horizontal tubular boilers and the installation of such boilers in accordance with good practice, but without any unnecessary frills. As stated before, many of our new setting plans are now completed and available for distribution to our friends upon request. Any inquiries regarding special features in connection with this general subject will receive the best attention of our Engineering Department at any time.

Improving the Saccharimeter.*

Foreign and American Instruments Discussed—Some Criticisms and Recommendations.

By C. A. BROWNE.[1]

A leading expert in the manufacture of chemical apparatus in this country recently made the statement that the high-water mark period for laboratory instruments, when the purchaser could get the highest standard of excellence for the least money, was reached in the years immediately preceding the late war. The user of apparatus, in his present state of desperation, when the lower possibilities of achievement compel him to accept either inferior instruments or none, looks back upon this pre-war period as a sort of golden age. No one has probably felt the effects of this decline in excellence more acutely than the sugar chemist. During the recent saccharimeter famine it was amazing to note the number of antiquated polariscopes that suddenly emerged from their dusty hiding places. Old instruments of the Duboscq, Scheibler and Mitscherlich types were lacquered up and sold at a handsome figure. An accuracy within three-tenths was cheerfully accepted where an error of one-tenth would previously have meant indignant rejection. Several purchasers of these old instruments brought their finds to the writer's laboratory for examination and some very interesting, as well as amusing, facts were brought to light as a result of this inspection. We must pass over all this, however, and confine our discussion to the observations made upon five different types of saccharimeters with which manufacturers in America, England, France, Germany and Bohemia are attempting to relieve the present shortage.

The first pinch of the war in the experience of American sugar chemists was the difficulty in replacing some of the most ordinary polariscope accessories, such as tubes and tube cover glasses. The case of the cover glass, the simplest piece of apparatus which sugar chemists employ, is instructive, as it offers an excellent illustration of the difficulties which suddenly confronted us. The first substitutes offered by dealers in place of the regulation covers were discs of ordinary window glass, which sold for the magnificent sum of 25 cents apiece. They contained numerous flaws, their surfaces were not plane parallel, and their deep green color impaired the intensity of the light in the field. But for a time, fortunately a brief one, these were the only covers available and chemists had to use them or do without. With the manufacture of optical glass in this country, instrument makers were able to take a long step in advance. Cover glasses were so improved that, as regards optical properties and plane parallelism, they were practically perfect, but as regards durability, they were still inferior

* Sugar, June, 1920.

[1] President Society of American Sugar Chemists and Technologists, known as the Sugar Section of the American Chemical Society. From an address delivered before the fifty-ninth meeting of that organization in St. Louis, April 15, 1920.

to the old pre-war standard. They split and cleaved easily around the edge; they cost twice as much as the old covers and their life was only about one-quarter as long. After some experimenting it was found that, by more careful annealing and by bevelling the sharp edges of the glass slightly, these defects of fracture could be removed, so that we have finally domestic cover glasses equal to those which were imported before the war.

This illustration of the cover glass is typical and it applies to every single feature of the saccharimeter. The perfection of any instrument is a process of slow growth and evolution and manufacturers who enter a new field must acquire and accumulate experience.

Coming now to the saccharimeter itself, let us consider first the question of general construction, of which there are two distinct types: the open construction, or French type, and the closed construction, or German type of instrument. Each of these types has certain distinct advantages as well as certain distinct disadvantages. The open construction has the advantage of accessibility of parts, and the French saccharimeters can usually be very easily dissected, in some cases without the necessity of removing a screw, the various parts slipping or turning into position. Easy accessibility is desirable in tropical countries, where the prisms require frequent attention, owing to the attacks of fungi which, unless quickly removed, will soon ruin the instrument. It is also desirable in remote localities, in order that damaged parts may be easily detached and sent away for repairs without the necessity of shipping the whole instrument. Objections to the open construction are that it does not exclude dust, that contamination of the wedges, etc, with drops of spilled solution is more easy, that it induces frequent tampering, and that it prevents securing the rigidity necessary for preserving the accurate permanent alignment of the optical parts. These objections to the open construction are all valid, but the advocates of the closed construction have gone too far in the opposite direction. I would criticize especially a familiar model of the closed type in which the parts are fastened in with such a multitude of fittings and screws that it is a day's task to dissect the instrument and reassemble the parts. The most common necessary operation of removing the splash glasses requires the use of a screw driver and, as one of our number has expressed it, "of much profanity." On one recent saccharimeter of the closed type the screw for adjusting the scale is enclosed within the protection case which covers the wedges, so that the rim of the case must be unscrewed and removed before the regulating pin can be turned. Such a contrivance may prevent tampering with the scale, a common fault of young chemists, but will defeat its own purpose in the end, for users of the instrument will soon remove the protection case once for all rather than waste thirty precious minutes every few days to make an adjustment which, through a covered hole in the case, could be made in thirty seconds. There is a happy medium between the closed and open construction toward which manufacturers should aim. The recent model of French saccharimeters shows a tendency toward such a compromise, and the saccharimeter of the future will no doubt combine as many as possible of the advantages, with as few as possible of the disadvantages, of each type.

One other important matter of general construction, which manufacturers should keep in mind, is the observance of a certain conformity with general usage in such details as height, width of trough, etc. The departure of some of the newer instruments from common usage will mean trouble and expense for some laboratories in such matters as making new openings in partition walls for illuminating the saccharimeter, or purchasing extra tubes that will fit troughs of a different diameter. It is a great advantage, and in some laboratories a necessity, to be able to use tubes interchangeably, as in the comparison of readings on different instruments, and this cannot be done when the width of trough varies, as it does on some of the newer types of saccharimeters, from less than 30 mm. to over 50 mm.

Leaving general construction we will discuss next a few of the special features of saccharimeter design which require attention, and the most important of these is the polarizer.

The most accurate polarizer for quartz wedge saccharimeters is generally admitted to be the Lippich. The extreme fragility of the half-prism of this type of polarizer is, however, a most serious defect. The sharp edge of the small prism, which forms the dividing line of the field, is very apt to become shattered, often from no apparent cause. I have had three instances of this in my own experience and the testimony of sugar chemists generally is very similar. An establishment in New York, which repairs a great many saccharimeters, gives, disruption of the Lippich half-prism as the most common cause of trouble. When this damage occurs, the saccharimeter is either rendered useless or the accuracy of reading is so much diminished that the initial advantage of the Lippich polarizer is lost. The Jellet-Cornu polarizer, while less sensitive than the Lippich in setting the field, has the advantage of much greater durability. The diminished sensitiveness is frequently the result of too heavy a line of division in the field, due either to too thick a film of balsam between the halves of the prism or to imperfect alignment. On some of the newer saccharimeters these difficulties seem to have been largely overcome, with a great increase in the accuracy of reading.

The French saccharimeters still employ the Laurent polarizer with the quartz half-wave plate. This system has the great advantage of simplicity and of permitting adjustment of the half-shadow angle to any desired degree of brightness with only a very small addition in cost to the instrument. On the other hand, the Laurent system being primarily intended for monochromatic light of one wave length, is not so well suited to the white light requirements of a saccharimeter, as the Lippich and Jellet-Cornu polarizers, even when using a bichromate light filter. The latest saccharimeters with the Laurent polarizer have simple devices for balancing the color inequalities of the field by a slight rotation of the analyzer, but the personal equation factor is not thus entirely equalized, so that the field may appear uniform to one person and irregular to another. The personal equation factor, it should be stated, enters more or less into all saccharimetric measurements where white light is used, no matter what the type of polarizer.

The size of the fixed half-shadow angle for a non-adjustable polarizing

system is a point upon which some manufacturers differ. For a charge of 26 grams in 100 cc. the fixed half-shadow angle for the miscellaneous class of products tested in a sugar and food laboratory ought to be about 7 degrees. Yet one manufacturer is putting out a saccharimeter with a half-shadow angle of 5 degrees, which is much too low for the polarization of dark colored products, and he defends this selection on the ground of increased accuracy in matching the field, stating that if solutions are too dark for this angle they should be clarified more completely. This manufacturer makes, however, the false assumption that the error due to increasing the quantity of clarifying agent is less than the error produced by increasing the half-shadow angle. It is not surprising that some of these new 5 degree angle instruments have been returned to the maker as not usable. Such mistakes as these could be avoided if manufacturers would first subject an undeveloped instrument to a thorough practical test before putting it upon the market. This necessary precaution would protect them against the damaging reports which circulate upon the rejection of a new type of instrument.

All of the recent types of saccharimeters have the double field and this seems to be in complete agreement with the opinion of those who have to make continual use of the instrument in commercial work.

The point upon which, perhaps, most uncertainty was felt about the new saccharimeters was the optical purity of the quartz in the wedges. It had been asserted that the supply of quartz sufficiently pure for cutting good wedges was about exhausted. The length of an ordinary wedge is about 30 mm., and, as far back as twenty years, Landolt[1] made the statement that to possess an optically pure quartz wedge of this length must be considered a piece of rare good luck. The situation would not seem, however, to be quite as bad as represented, and a careful examination of some of the new saccharimeters with a control tube shows that the inaccuracies of scale due to optical imperfections in the quartz wedge are less than 0.05 degree.

It is to be regretted that some manufacturers in the construction of the saccharimeter scale have not had a sufficient regard for the comfort of the observer's eye. One of the new scales examined consisted of very fine lines, ruled upon metal that was scratched and unpolished, and hence very difficult to read. The best of the new scales is a modification of the ground glass scale illuminated by softened transmitted light. A unique feature of this scale is the slight overlapping of the lines of the vernier upon the lines of the scale, which permits the easy estimation of slight differences. A vernier line is easily seen to be continuous with a scale line, or separated from it by a full, half, or quarter break, so that the observer can read to 0.025 degree without difficulty.

The greatest length of any scale is afforded by a French saccharimeter, in which the two equal sized wedges of the quartz compensation are driven past

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[1] Das optische Drehungsvermögen, 2nd Edit., p. 339 (1898).

each other in opposite directions by the action of a double rack and pinion, the scale being upon one wedge and the magnifying glass and vernier upon the other. This permits making a scale of double the ordinary length. Such a construction is, of course, limited to instruments of the open type.

Manufacturers of the newer saccharimeters show somewhat different ideas about trough construction. Reference has already been made to the inconvenience resulting from variations in the diameter of trough. The separation of the trough by a small space from the rest of the instrument is an excellent feature of one saccharimeter, as it protects the analyzer and polarizer against the transmission of heat, when polarizing hot solutions, and also by offering a means of drainage prevents accidental flooding of the optical parts when solutions are spilled through breakage or leakage of tubes or otherwise. Some of the new saccharimeters have a trough with a wedge-shaped cross section instead of the familiar semi-circular form. A wedge shape presents no disadvantage with ordinary tubes, but with tubes having projecting attachments, such as the control tube, the inversion tube and continuous tube, the equilibrium in a wedge form is very unstable; the sudden tilting, for example, of an inversion tube, in which a thermometer is placed, may lead to an accident. For this reason the old semi-circular form of trough, which conforms more closely to the outlines of the tube, is generally to be preferred.

Two of the new saccharimeters examined had methods for attaching the illuminating device directly to the instrument. This system has an advantage in that the alignment of the instrument with the lamp is not disturbed by moving, but it has the disadvantage, unless suitable precautions are taken, of communicating heat to the polarizer. One new instrument had a small attachable electric lamp, the current to which from a battery of dry cells could be turned off after each reading by a switch on the front of the instrument. But where readings have to be made for hours at a time with one tube following another, the lamp must burn continuously and, in such cases, the polarizer becomes overheated. It is for this, as well as for other reasons, that the small attachable electric light system of illumination has not generally been favored by chemists. On another new type of saccharimeter the lamp was supported by a long bracket fastened to the base of the saccharimeter and this device was found to protect the polarizer perfectly against heat transmission even after several hours' burning of the light.

All of the newer saccharimeters which were examined offered a means of substituting a section of bichromate crystal or of bichromate colored glass in place of the troublesome cell of bichromate solution. This feature will be found a decided convenience in many commercial laboratories, although for purposes of standardization, or of highly accurate measurement, the regulation cell of bichromate solution should always be the standard of reference.

As to the question of scale standard: One of the more recent types of saccharimeters used a normal weight of 20 grams and two a normal

weight of 26 grams. Manufacturers express themselves as most anxious to please their customers in the matter of scale standards, but are hampered by the lack of sufficient knowledge in regard to the rotation value for the 100 degree point of each scale. We have two opposing official standards for the 26 gram German scale, and there are similar disputes about the French scale. These differences are no doubt due in considerable part to the influence of personal equation, first on the part of the technician who fixes the 100 degree point of the scale, and, second, on the part of the observer who reads the sugar solution, there being slight differences of scale adjustment or of reading on account of the varying sensitiveness of individual eyes to the slight color disturbances in the field of all white light saccharimeters.

The fixing of the rotation value for each particular scale should be settled in the same way; atomic weights, for instance, are fixed by international agreement. No less than twenty-nine determinations by different experimenters enter into the average made by Clarke for the atomic weight of silver. Let measurements of the rotation constant of the saccharimeter scale be made in as many different physical laboratories as possible under the best controllable conditions, and let the International Commission for Uniform Methods of Sugar Analysis prescribe an average value which shall govern the standardization of all saccharimeters. The value thus obtained may not be perfectly true for many individual eyes, but it will be truer for the average eye than the results of a single set of experiments.

The outlook for the manufacture of accurate saccharimeters in countries outside of Central Europe is believed to be most encouraging. The defects which have been noted are mostly in minor matters of construction and can easily be corrected. Manufacturers must necessarily be given time to acquire and accumulate experience. The users and manufacturers of scientific apparatus should work together in a critical yet friendly spirit of cooperation. It was by the intensest kind of such cooperation that the manufacturers of Central Europe attained their high position and manufacturers in other countries must follow a similar course if they are to achieve the greatest success.

[R. S. N.]

THE HAWAIIAN PLANTERS' RECORD

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Pahala Blight.

By H. L. Lyon.

Pahala blight of the sugar cane is a type of chlorosis induced by a factor or factors resident in the soil.

Chlorosis signifies a derangement of the chlorophyll (green coloring matter) in a plant which becomes apparent through the diminution, destruction or total absence of the green color in the tissues. Five types of chlorosis appear in Hawaiian cane fields.

Inherent chlorosis is due to a loss on the part of the protoplasm, or living substance, of the ability to produce chlorophyll. If the living substance throughout all of the embryonic tissue of a cane plant loses the power to generate chlorophyll, this tissue can then give rise to white leaves only and the plant soon dies of starvation through inability to compound starch and sugar. When canes are grown from seed on any considerable scale, individual seedlings will frequently appear which never produce any green leaves at all, their tissues throughout being white or yellowish. All such seedlings die when the nourishment supplied by the seed is exhausted.

When loss of ability to generate chlorophyll extends to only a portion of the embryonic tissue of a shoot, the result is leaves with white and green stripes of varying widths, and we say that the leaves are variegated. Many well-known varieties of cane habitually produce variegated leaves, and an occasional variegated shoot may be found in any variety. When variegated canes are grown on any considerable scale, individual shoots are certain to occur, the embryonic tissue of which has entirely lost the chlorophyll-producing power. These shoots have white leaves and survive only through support derived from other shoots in the stool. Needless to say, it is impossible to propagate a cane with only white leaves.

The well-known Yellow Stripe disease is an infectious chlorosis attacking canes of all ages, of all varieties and in all districts. It is caused by some parasitic agent as yet undetermined.

Lime-induced chlorosis appears in canes grown in soil containing an excess

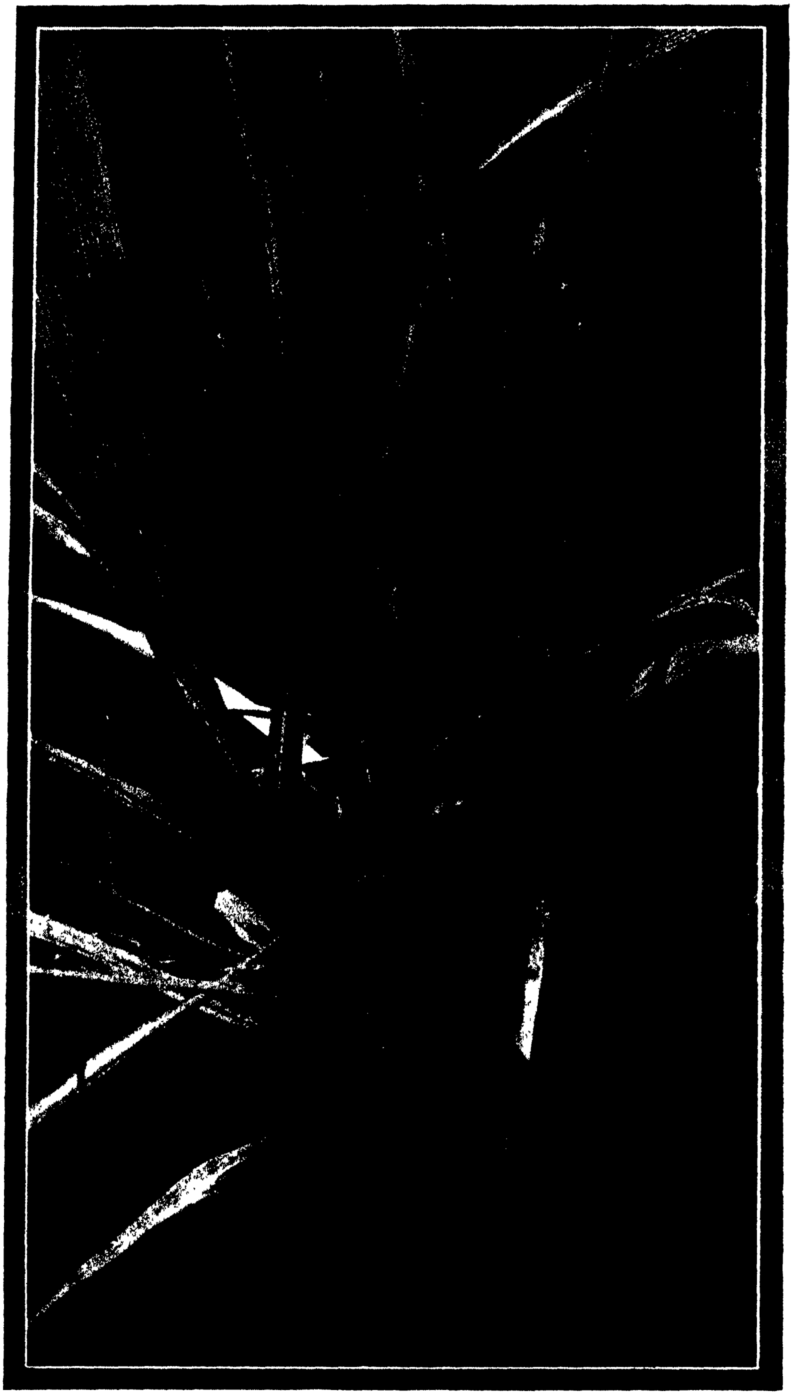

Fig. 1. A stool of cane in an advanced stage of Pahala Blight.

of calcium carbonate. It only occurs in lowland fields at points where there is an outcrop of ancient coral. Under such conditions canes once green may lose all of their chlorophyll, the leaves becoming quite white. Cuttings from such canes when planted in good soil give rise to normal green shoots.

A chlorosis of young ratoon shoots occurs quite extensively, particularly on the Island of Oahu. In this case the leaves of the young shoots are quite white when they unroll and they may remain so and die or they may eventually become green. If the first shoots to appear from the old stool do not recover they are soon followed by green shoots which grow normally, so while this chlorosis may cause a delay in the starting of the ratoon crop, it does not, as a rule, appreciably affect the ultimate stand.

Pahala blight is an induced chlorosis which may afflict a cane plant at any stage in its growth. It is characterized by paling or whitening of the tissue of the leaves in definite narrow stripes, these stripes alternating with green stripes of about equal width as may be seen in Fig. 1 and the illustration on the cover. This type of chlorosis has been noted in cane fields in various parts of these Islands and also in other cane-growing countries. In most localities it is but a temporary derangement of the green tissues in the leaves, which eventually regain their normal green color and the plant suffers no permanent injury. In Pahala, however, this type of chlorosis appears regularly in every crop on certain fields and often persists for such periods as to very seriously injure the crop; in fact, it not infrequently causes the complete failure of the canes on considerable areas.

Data Previously Recorded.

Pahala blight has been known as long as cane has been grown on a commercial scale in Pahala. At a very early date it was definitely established that the disease was not spread throughout the district, but occurred on certain sharply-defined areas only. It was also early noted that the trouble seemed to develop to its greatest intensity only when certain climatic conditions prevailed, the essential factors being continuous cloudy, wet weather, and that the cessation of these conditions was always followed by immediate improvement among diseased canes.

Pahala blight was studied by Dr. N. A. Cobb* during 1905-1906. He named it "*leaf-splitting blight*" and published a very full description accompanied by some excellent illustrations which tell better than words how the disease may be recognized in the field. His description is slightly inaccurate in certain details, however, and his conclusion quite erroneous in so far as the cause of the disease is concerned. He describes a new fungus, *Mycosphaerella striatiformans*, as a parasite directly responsible for the malady. This fungus proves to be a saprophyte which enters the tissues of a cane leaf only after these tissues have died from Pahala blight or some other cause. During the early stages of Pahala blight no parasitic organisms can be found in the affected tissues, and *M. striatiformans* does not, by any means, appear in all leaves that succumb to Pahala blight.

* Experiment Station, H. S. P. A., Division of Pathology and Phys. Bulletin 5, pp. 93 106, Bulletin 6, p. 103, pl. VII.

Structure of a Cane Leaf.

To clearly understand the exact course of the disease in a cane leaf we must first understand the structure of the leaf and the disposition of the chlorophyll therein.

Vascular bundles constitute the framework about which the other tissues of the cane leaf are disposed, certain tissues being associated with each bundle according to a rather definite plan, forming a structural unit. The bundles are of several different sizes and the complexity of the unit increases with the size of the bundle around which it is built. The tissues associated together in one of these structural units may be noted by referring to Fig. 2. There is always present the essential vascular tissue, vessels and sieve tubes, which is completely surrounded by a layer of large cells with rather thick walls constituting the bundle sheath, and this in turn is enclosed in a layer of thin walled cells which are densely packed with chlorophyll.

Vascular tissue, bundle sheath and chlorophyllous tissue are the essential tissues always present in a structural unit of the leaf, no matter how small or how large that unit may be. Additional complexity is added to the larger units by an increase in the size and number of cells in each essential tissue and the interpolation of sclerotic tissue or fiber cells at various points to give mechanical strength to the unit, as seen at 6 and 9 in Fig. 2.

Now, in a cane leaf these structural units of different diameters run parallel and in such close proximity to each other as to form a continuous layer throughout the blade of the leaf. In this layer of parallel units there occur at uniform intervals very large units which we may term major units. These major units are practically cylindrical and of such large diameter that they cause the upper epidermis to be elevated in order to accommodate them. They always contain a large amount of sclerotic tissue and constitute the chief strengthening members in the leaf. They occur from 2 to 3 millimeters apart and run quite parallel through the wings of the leaf blade.

From the foregoing description of the structure of a cane leaf it will be noted that the chlorophyll is segregated in a very definite tissue which is disposed in a layer around each and every vascular bundle in the leaf.

In Pahala blight it is the chlorophyll that is directly affected.

Pathogenesis.

Pahala blight is in effect a bleaching and destruction of the chlorophyll. As a rule the chlorophyllous tissues around the minor vascular bundles only are affected, the green tissues around the major bundles becoming involved only at a late stage in the disease. As a result a newly affected leaf displays a very definite striped appearance, green stripes alternating with yellowish-green or white stripes.

In the affected tissues the chloroplasts first lose their definite outline, then run together in a pale yellowish green mass and finally lose all semblance of green color.

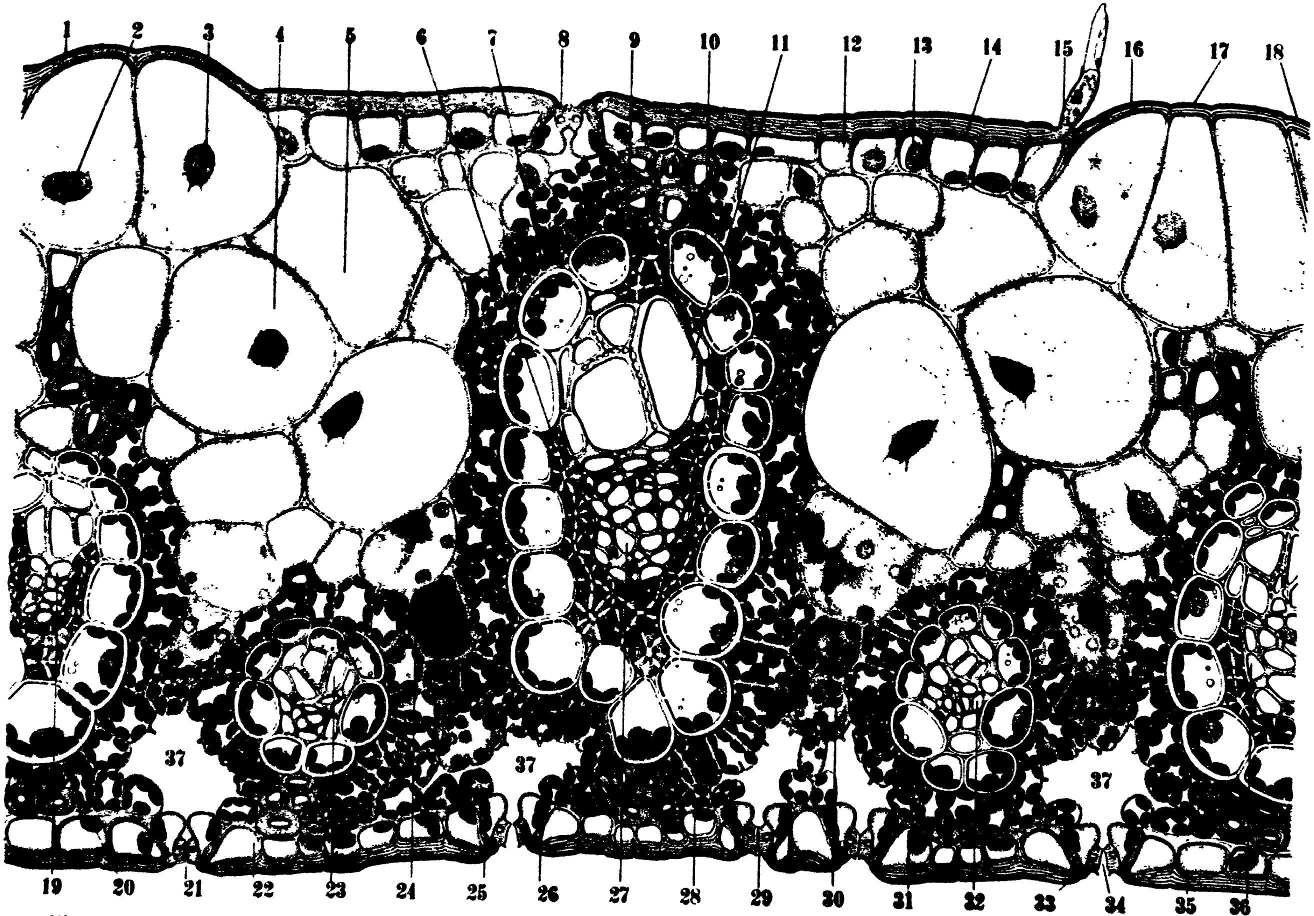

Fig. 2. Cross-section of a small portion of a cane leaf showing several minor vascular bundles. The vascular tissue is pointed out at 11, 19, 23, 27, 32 and 36; the bundle-sheath at 10; the chlorophyllous cells at 7 and sclerotic cells at 6 and 9. The chloroplastids, which are green in the leaf, are shown as black bodies in the figure.

The first indication of an attack of Pahala blight noticeable in a cane leaf is a paling or bleaching of the green tissue at the proximal ends of the minor vascular bundles. The bleaching proceeds upward and outward through the blades of the leaf along these bundles, producing light stripes of uniform width which may eventually extend to the very margin of the leaf. The progress of the disease may be slow or very rapid. In some cases the paling of the tissue in the stripe is very gradual and may not proceed beyond a light greenish yellow; in other cases the paling is very rapid, the tissues being quickly bleached to a sickly, yellowish white.

A cane shoot may show a mild case of Pahala blight, continue in the same condition for months and eventually recover. Then again the disease may reach an acute stage only a short time after the first symptoms have become apparent, but the shoot usually lingers on for months before it finally succumbs. If the chloroplasts are seriously injured the tissues never recover, but die and are soon invaded by various saprophytic fungi. When canes become seriously affected by the blight they stop growing and remain practically dormant until the blight-factor ceases to operate, then they do not recover by rehabilitating the old tissue, but produce new and healthy tissue. Consequently canes often show a very abrupt transition from diseased to healthy tissue. One leaf may be badly marked by the blight and the very next younger leaf show no signs of the blight at all. Then, again, the upper portion of a leaf may be distinctly blighted, while the basal portion is quite free from blight. In such a case the basal portion has been produced after the blight factor ceased to operate.

Investigation of Pahala Blight.

The actual cause of Pahala blight has not been determined. Early in our experience with the malady, however, we obtained certain evidence which indicated that the bleaching of the green tissues in the leaves was due to some deleterious chemical agent taken up from the soil by the plant.

Analyses of soil from areas where the disease annually occurs have failed to reveal the causal factor. Tub experiments conducted in Honolulu on soils from blight areas have yielded only negative results. Finally we decided to conduct comprehensive experiments with these soils in the field. In these experiments we aim to apply laboratory methods but at the same time maintain field conditions.

The installation, progress and results to date of the first experiment of this nature are carefully described by Mr. W. L. S. Williams in the following pages.

This experiment gives us the first positive evidence yet obtained on the exact location of the causal factor of Pahala blight. Incidentally, it also shows what these lands actually produce in comparison with what they would produce if the blight factor could be nullified or eliminated.

Pahala Blight Investigations.

By W. L. S. Williams.

Hawaiian Agricultural Co. Observation Test D.*

Object. To avoid confusion and misunderstanding, it should be stated here that the object of this experiment is to obtain information, and that none of the treatments employed have at any time been considered as practical methods of combatting Pahala Blight. The experiment was designed to answer the following questions:

1. Can Pahala Blight be corrected by the incorporation of organic matter in the soil?
2. Is Pahala Blight caused by poisonous gases rising into the surface soil?
3. Does the cause of Pahala Blight reside in the surface soil or in the sub-soil?

Description of Experiment. For the location of the experiment, a section of Mission Field at an elevation of 1,500 feet above sea level was selected. This field is recognized at Hawaiian Agricultural Co. as being one of the most seriously and continuously blighted fields on the plantation. The crop harvested here in 1919 was Yellow Bamboo plant. It yielded an average of but 14 tons of cane per acre. This crop failure was due solely to the damage caused by Pahala Blight. On the section of the field where the experiment was installed the cane had been entirely killed out by the blight.

The variety of cane selected for the experiment was Yellow Bamboo, this variety being considered the most susceptible to blight. A second reason for planting this variety was the desire to avoid any possible complications induced by a rotation of varieties, the previous crop having also been Yellow Bamboo.

The installation of the experiment consisted in removing all surface soil from a space ten feet wide and eighty feet long. The depth of this surface soil varied from 12 inches at the upper end to 20 inches at the lower end. The surface soil was a fine sandy loam, while the sub-soil was a reddish brown clay loam, so the dividing line was easily followed. The sides of this excavation were entirely lined with half-ply rubberoid roofing paper, and the whole subdivided by strips of the same material into four plots, 10x20 feet in size. The purpose of the roofing paper was to prevent the lateral movement of soil water and gases from one plot to another, limiting this movement to the space directly below each plot. The plots were numbered from the upper end — 1, 2, 3, and 4.

1. In plot No. 1 (hereafter known as Organic Plot) a six-inch layer of mixed stable manure, press cake, and bagasse was inserted. This layer was then covered to the original level with the previously excavated surface soil. The purpose of this plot was to test the corrective value of organic matter for Pahala Blight.

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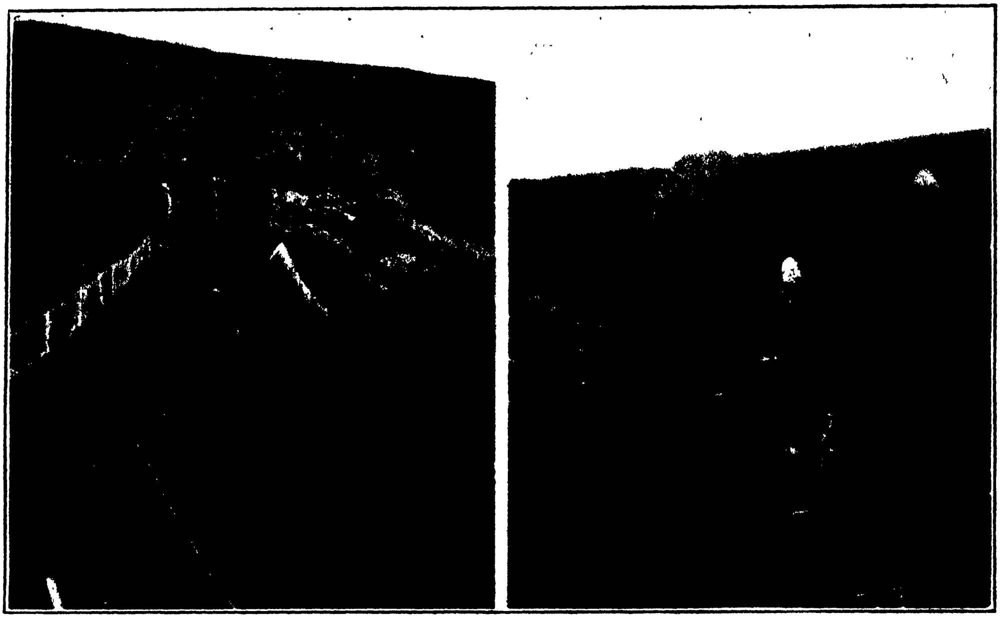
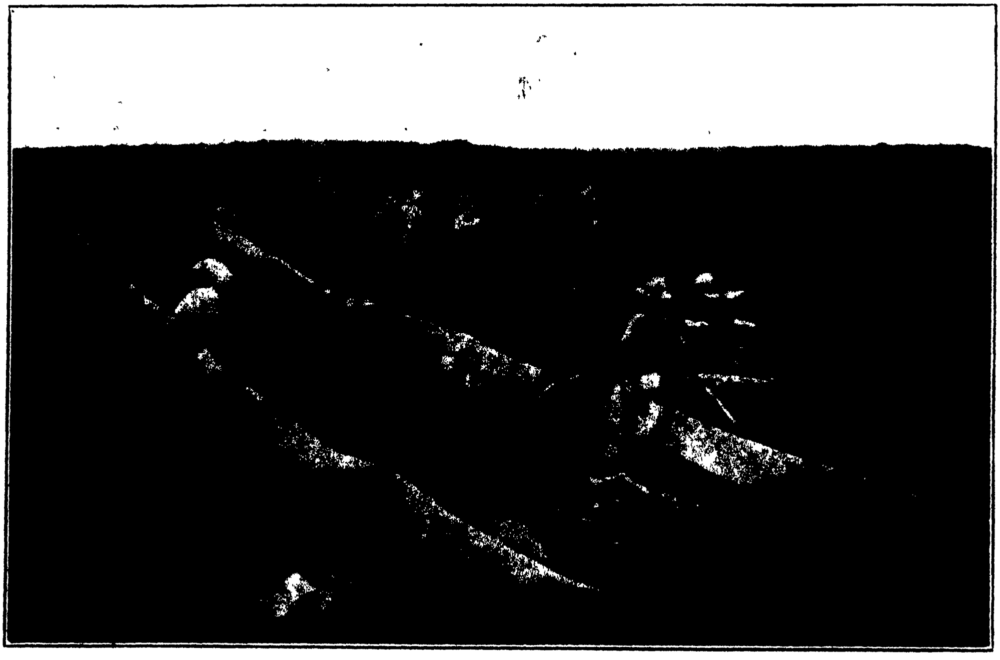
* Experiment planned by H. L. Lyon.
Experiment laid out by W. P. Alexander and W. L. S. Williams.

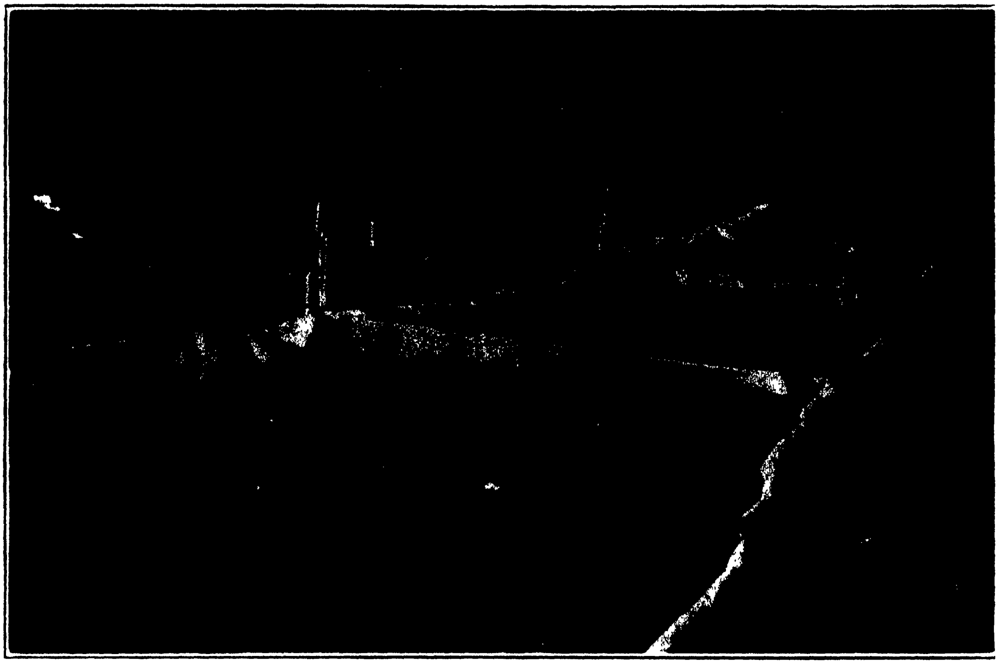
Installation of Excavation Experiments.



Photographs showing excavation made by removal of all surface soil from area where cane had previously failed to grow on account of Pahala Blight.



The excavation was divided into four compartments, which were lined with half-ply rubberoid roofing paper, wire netting being used to form a backing for the paper. The purpose of the roofing paper was to prevent the lateral movement of soil-water and gases from one plot to another.



All compartments are shown completely filled and ready to be planted with cane.

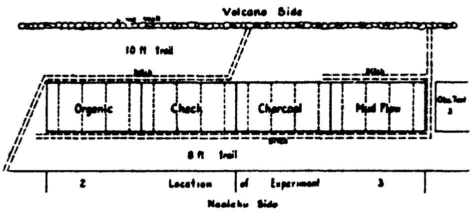
Photograph taken September 29, 1919. Mud flow plot is in foreground.

2. In plot No. 2 (hereafter known as Check Plot) the excavated surface soil was replaced without further treatment. The purpose of this plot was to act as a check on the other plots and to note the effect of handling the surface soil.

3. In plot No. 3 (hereafter known as Charcoal Plot) a six-inch layer of crushed charcoal was inserted. The charcoal was then covered to the original level with the previously excavated surface soil. The purpose of the charcoal was to act as a filter, to prevent injurious gases from rising into the surface soil from below.

4. In plot No. 4 (hereafter known as Mud Flow Plot) the excavation was filled with soil transported from Mud Flow Field—a field in which blight has never been known to occur. The purpose of this plot was to determine if the blight were induced by the sub-soil or by poisonous gases arising into the surface soil.

After completing the above, Yellow Bamboo seed was planted in all plots. Each plot had four lines of cane, each line 5 feet wide and 10 feet long. The following sketch shows the layout complete:



Observations have been made from time to time of the growth of cane, the number of shoots, and the degree of blight in the four plots. The following table gives the data from which graphical charts were plotted for the first year's results:

Date of Observation	Height of Cane to Tips of Leaves				Total Number of Shoots			
	Organic	Check	Charcoal	Mud Flow	Organic	Check	Charcoal	Mud Flow
	1	2	3	4	1	2	3	4
ugust 11, 1919	....	....	....	....	....	....	....	....
eptember 10, 1919 ...	14"	8"	10"	10"	83	40	48	92
ptember 29, 1919 ...	20"	12"	12"	12"	93	55	67	109
ctober 15, 1919	24"	12"	18"	18"	101	56	73	115
ovember 3, 1919	36"	24"	30"	30"	151	64	74	132
anuary 14, 1920	60"	30"	30"	36"	....	....	....	....
ebruary 18, 1920	....	....	....	....	....	....	....	....
pril 2, 1920	....	....	....	....	....	....	....	....
ay 11, 1920	....	....	....	....	....	....	....	....
ly 23, 1920	150"	36"	48"	114"	211	91	130	194

Date of Observation	Percentage of Blighted Shoots			
	Organic	Check	Charcoal	Mud Flow
	1	2	3	4
August 11, 1919	.....	.....	.....	.....
September 10, 1919	.....	.....	.....	.....
September 29, 1919	.....	.....	.....	.....
October 15, 1919	3.96	7.14	24.66	.....
November 3, 1919	4.63	51.56	48.65	.....
January 14, 1920	2.0	100.0	100.0	.....
February 18, 1920	1.15	100.0	100.0	1.28
April 2, 1920	16.66	100.0	100.0	4.22
May 11, 1920	14.43	100.0	100.0	2.84
July 23, 1920	12.32	100.0	100.0	.....

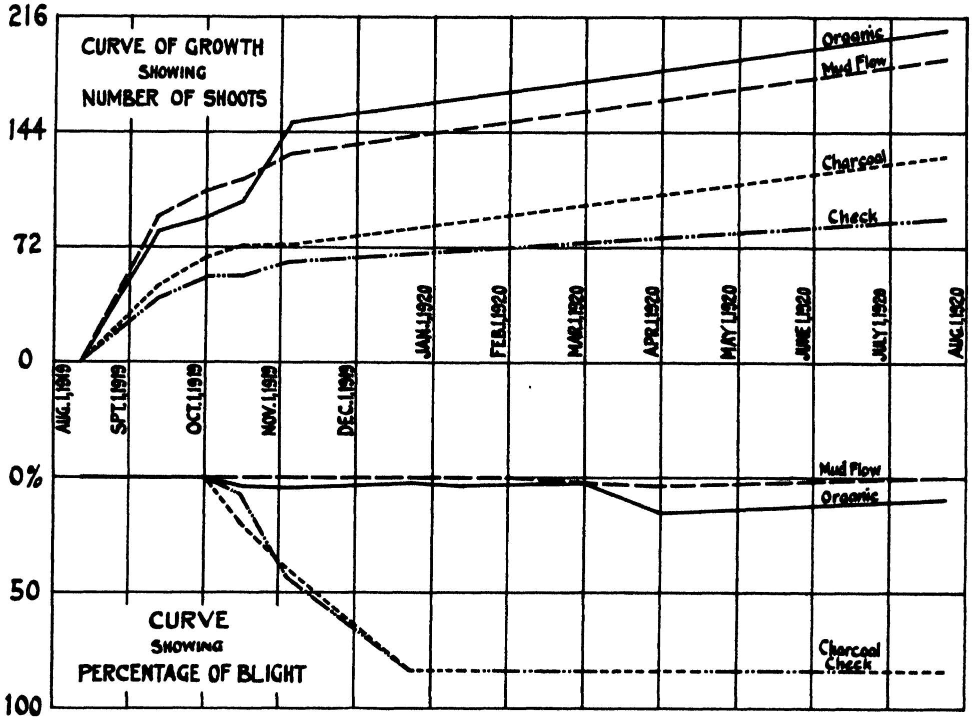
It should be noted here that the blighted canes in the Organic Plot noted in October and November were scattered throughout the plot, while all blighted shoots in the Organic and Mud Flow Plots noted after January were entirely confined to the sides and ends of the plots, none appearing in the central parts.

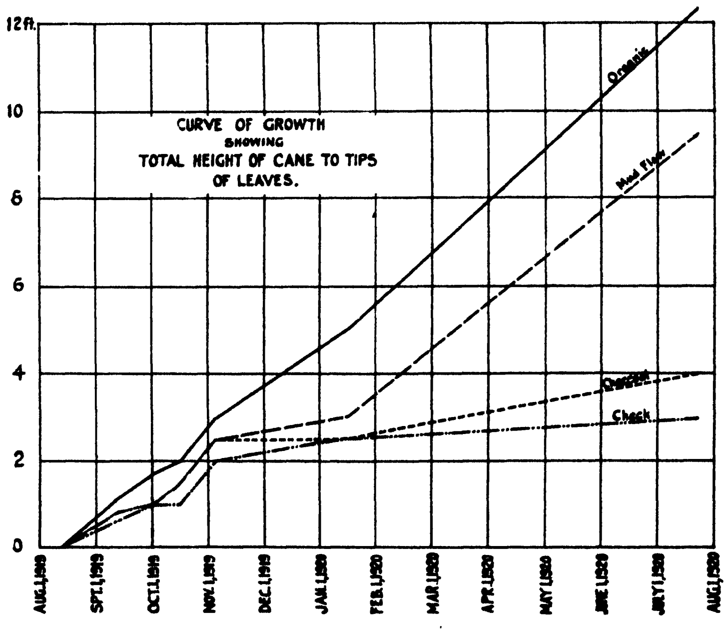
On July 23d, 1920, final observations and measurements were made which are tabulated below:

Plots	Number of Shoots or Sticks	Average Length of Stick	Average Circum. of Stick	Percentage Blight	Total Height to Tips of Leaves	Calculated Tons Cane per Acre
1. Organic	211	47.9	4.415	12.32	12½ ft.	49.8
2. Check	91	0.0	0.0	100.00	3 ft.	0.0
3. Charcoal	130	3.0	2.056	100.00	4 ft.	0.5
4. Mud Flow ..	194	29.2	4.100	0.00	9½ ft.	24.4

During the year two applications of complete fertilizer containing 11% nitrogen have been applied uniformly to all plots, each application being at the rate of 500 lbs. per acre.

Results. The growth of cane as indicated by the height of the cane and the number of shoots shows that the Organic Plot has made an exceedingly rapid growth. The Mud Flow Plot has made practically a normal growth. Neither of these plots has been checked to any extent by blight. In the Check and Charcoal Plots, however, we find a total failure of the cane, due entirely to the ravages of Pahala Blight.



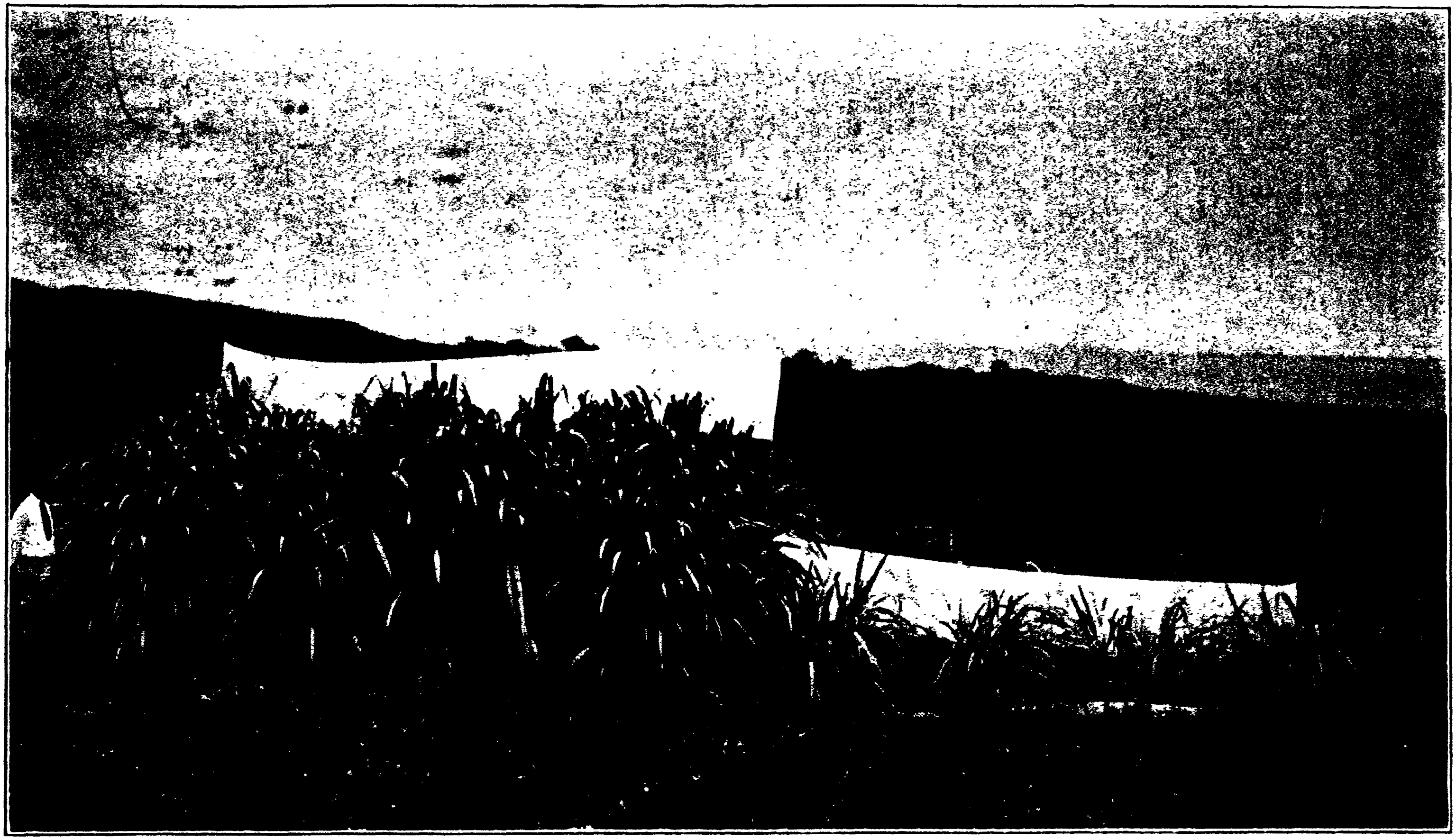


Showing length of stick.
July 23, 1920.

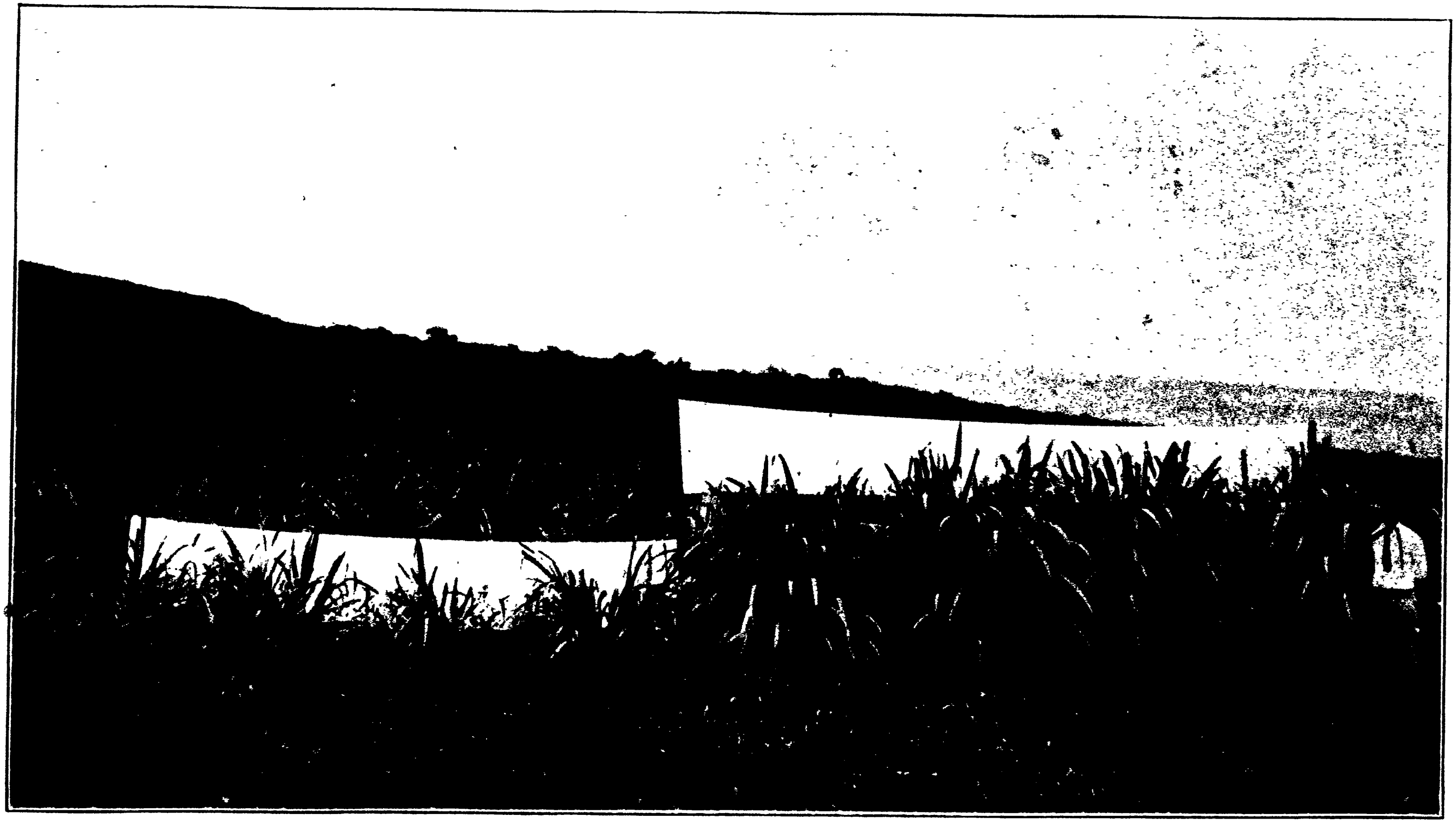
In the column of Percentage of Blighted Shoots we find none of the plots showing traces of blight until the end of two months after planting. It was noticed, however, that the cane in all plots had a very poor color up to the first application of fertilizer on September 29th. From the beginning of the third month, Organic, Check, and Charcoal Plots begin to show traces of blight. In the case of Organic Plot, the blight diminishes slightly until February, at which time all blighted shoots in the central part of the plot have recovered. From April on, a heavier blighting takes place in the Organic Plot, but entirely confined to the edges of the plot. In the cases of the Check and Charcoal Plots the blight progresses steadily from the first traces noted in October to a condition of 100% blight in January, from which condition there is no revival. With the Mud Flow Plot we see no traces of blight until February, when a few shoots around the edges of the plot become affected. This condition grows a little worse in April, but a slight diminution is noted in May, with total recovery of all shoots by July.

Conclusions. Taking up the three questions which the experiment was intended to answer we can conclude with certainty that:

1. Pahala Blight can be controlled, if not entirely corrected, by the incorporation of organic matter in the soil, as is shown by the results of the Organic Plot.
2. Pahala Blight is not caused by gases rising into the surface soil, as is shown by the failure of the cane in the Charcoal Plot and the success of the cane in the Mud Flow Plot.
3. The cause of Pahala Blight resides in the surface soil, as shown by the success of the cane in the Mud Flow Plot and the failure of the cane in the Check and Charcoal Plots.



We see here the results of incorporating organic matter. This photograph was taken on May 11, 1920, about ten months after the cane was planted. On the right is the cane in the check plot, which is 100% diseased with Pahala Blight, and has made no stick. On the left is seen the cane planted in the plot where organic matter was incorporated with the soil. The cane tips reach a height of 8½ feet.



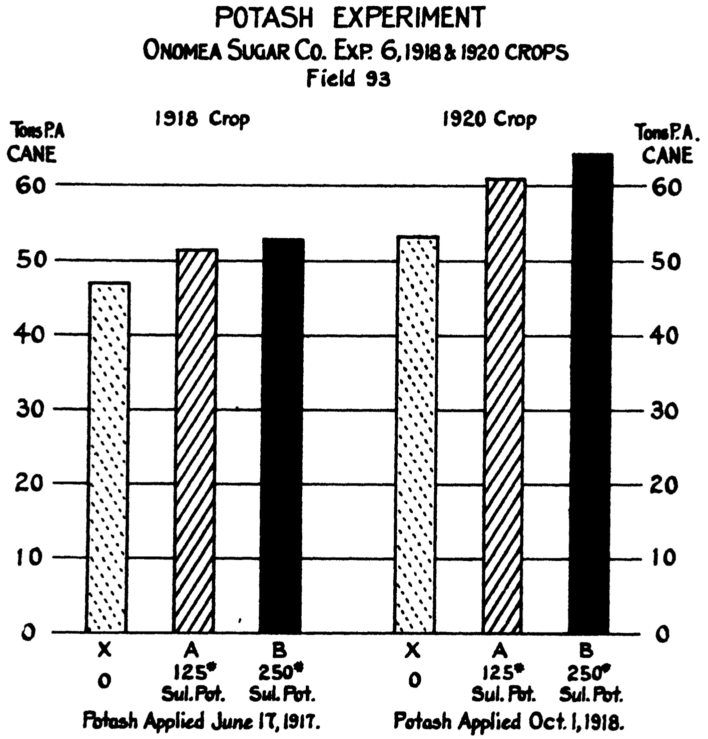
That the cause of Pahala Blight resides in the surface soil is shown by the success of the cane in the mud flow plot on the right. In this plot the excavation was filled with soil transplanted from a field in which the blight has never been known to occur. The cane has made a normal growth, and has demonstrated that the blight is not induced by the sub-soil, or by poisonous gases rising into the surface soil. On the left is seen the plot which had a six-inch layer of ground charcoal installed between the sub soil and surface soil. The purpose of the charcoal was to act as a filter to prevent injurious gases from rising into the surface soil from below. That such gases are not a factor has been proven here.

Potash Fertililzation Gives Consistent Gains at Onomea.

ONOMEA EXP. NO. 6, 1918 AND 1920 CROPS.

In this experiment a study was made of the value of varying amounts of potash as compared with no potash. The cane was Yellow Caledonia, second ratoons, long, for the 1918 crop.

This test was started in 1917, so that the potash for the 1918 crop was not applied until during the second growing season, June 15, 1917. For the 1920 crop, the potash was applied to the young cane on October 18, 1918. All plots received a uniform application of nitrogen of about 195 pounds per acre in three doses.

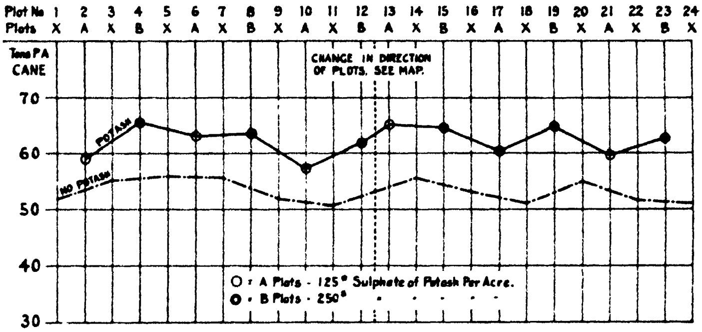


The potash applications and the yields for each treatment for the two crops are given below:

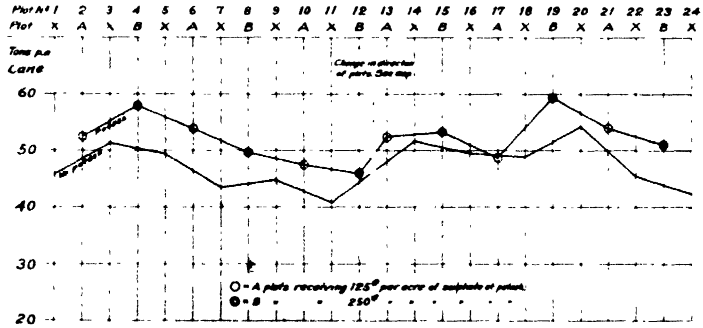
Plots	No. of Plots	Treatment, Lbs. per Acre	YIELDS PER ACRE					
			1918 Crop			1920 Crop		
			Cane	Q. R.	Sugar	Cane	Q. R.	Sugar
X	12	No potash	47.4	8.27	5.73	53.3	8.58	6.21
A	6	125 lbs. sul. pot..	51.6	8.47	6.09	60.9	8.88	6.86
B	6	250 lbs. sul. pot..	52.9	8.37	6.32	64.0	8.41	7.61

The results of the two harvests from this experiment are distinct and positive in favor of potash. In all cases the plots receiving potash produced more sugar per acre than the adjoining check plots. (See plot curve below.) The gains due to the potash were greater in the 1920 crop than in the 1918 crop. This is undoubtedly due to the fact that the potash was not applied to the 1918 crop until during the second growing season.

GAIN DUE TO POTASH
Onomea Sugar Co. Exp. 6, 1920 crop
Curve Showing Cane Yields Per Acre By Plots.



GAIN DUE TO POTASH
ONOMEA SUGAR CO. EXP. 6, 1918 crop
Curve showing cane yields per acre by plots.



Results of a similar nature were obtained last year from Onomea Experiments No. 8 and No. 9. For details see *Record*, Vol. XXI, pages 161 and 254.

A composite sample of the surface soil taken from Experiment No. 6 has an analysis of .214 total acid soluble K_2O.

DETAILS OF EXPERIMENT.

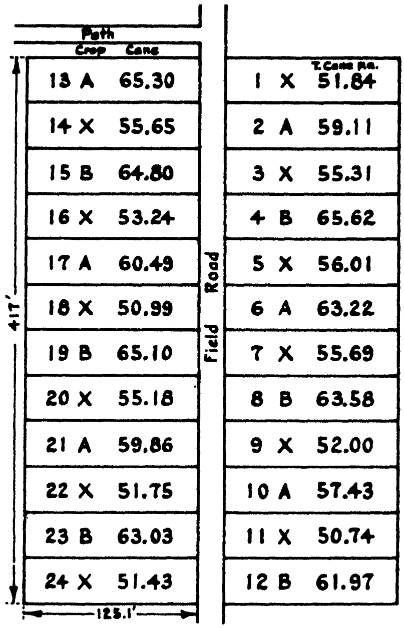
Object: 1. Comparing potash with no potash.
2. Comparing varying amounts of potash.

Location: Onomea Sugar Co., Field 93 (135-acre field).

Crop: Yellow Caledonia. 3rd ratoon, long.

POTASH EXPERIMENT

Onomea Sugar Co. Exp. 6, 1920 Crop
Field 93.



Layout: No. of plots, 24.
Area of plots, 1/10 acre each, consisting of 6 rows 5.79 feet wide and 125.1 feet long.

Summary Of Results

Plots	Sulphate of Potash Lbs. per acre	Yields Per Acre			Gain Over X	
		Cane	Q.R.	Sugar	Cane	Sugar
X	0	53.32	8.58	6.21		
A	125#	60.90	8.88	6.86	7.58	.65
B	250#	64.02	8.41	7.61	10.70	1.40

Plan: Fertilization:

Plots	No. of Plots	Oct. 18, 1918	Oct. 18, 1918	Feb. 6, 1919	May 16, 1919	Total Lbs. per Acre		
		Sulfate of Pot. per Acre	Lbs. W. I. per Acre	Lbs. N. S. per Acre	Lbs. N. S. per Acre	N.	P_2O_5	K_2O
X	12	0	500	500	450	193.75	40	0
A	6	125 lbs.	500	500	450	193.75	40	60
B	6	250 lbs.	500	500	450	193.75	40	120

W. I. = 9½% N., 8% P_2O_5.
N. S. = 15.5% N.

Experiment planned by L. D. Larsen.
Experiment laid out by W. P. Alexander.
Experiment fertilized by G. B. Grant and W. L. S. Williams.
Experiment harvested by W. L. S. Williams, July 29, 1920.

J. A. V. and W. P. A.

The Ewa Concrete Stove.

Industrial Service Bureau, H. S. P. A.

Fig. 1. Stove Factory, Ewa Plantation.

In order to abate the nuisance of open fires for cooking and to provide the labor with some degree of comfort in their kitchens, the concrete stove as shown in Plan 37, Industrial Service Bureau, has been adopted by Ewa, where stoves are being manufactured in large numbers.

Fig. 2. Stoves must season.

Three weeks are allowed for the stoves to season before they are placed on the bases, which are cast in place. Cast iron rings and plates are installed when the stove is set up.

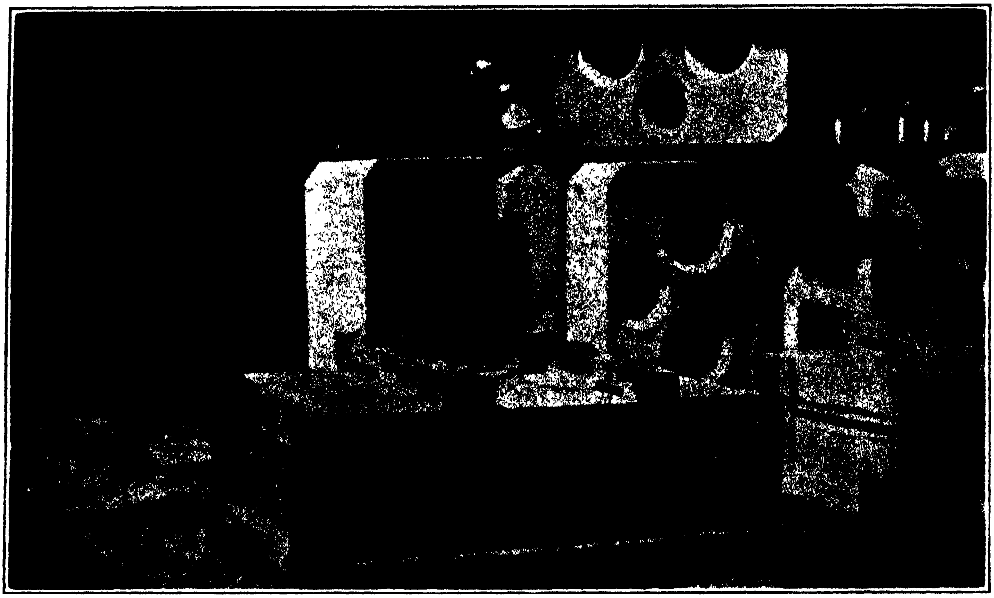


Fig. 3. Well-made Forms.

The forms used are carefully made and bolted together. The stove is cast upside down. Concrete is mixed in the following proportions: (The recess left for the cast iron rings is 5/8 inch deep, 1 inch wide. Outside ring should not be cemented in, as by removing same the large size rice cooker will fit nicely.)

Crushed fire brick 1 in. and smaller, using all sand from crusher	parts	4
Clean sharp sand	"	1
Portland cement	"	1
Fire clay	"	1/2

This mixture is used throughout, and the stoves are reinforced with 1/2-inch bars placed around the top.

Phosphoric Acid for Grove Farm—Lihue District.

GROVE FARM PLANTATION EXP. NO. 9 (1920 CROP).

This experiment is to determine the value of phosphoric acid on that part of the upper lands of Grove Farm Plantation lying on the slopes of Kilohana Crater. This same soil type extends to the mauka lands of Lihue, and to part of the homesteads back of Makee Sugar Co., so that it would be fair to expect the results of this experiment to apply to the same type of land on Lihue and Makee. Further, observation tests on the mauka lands of Lihue show decided response to phosphoric acid.

Fig. 1. No reverted phosphate.

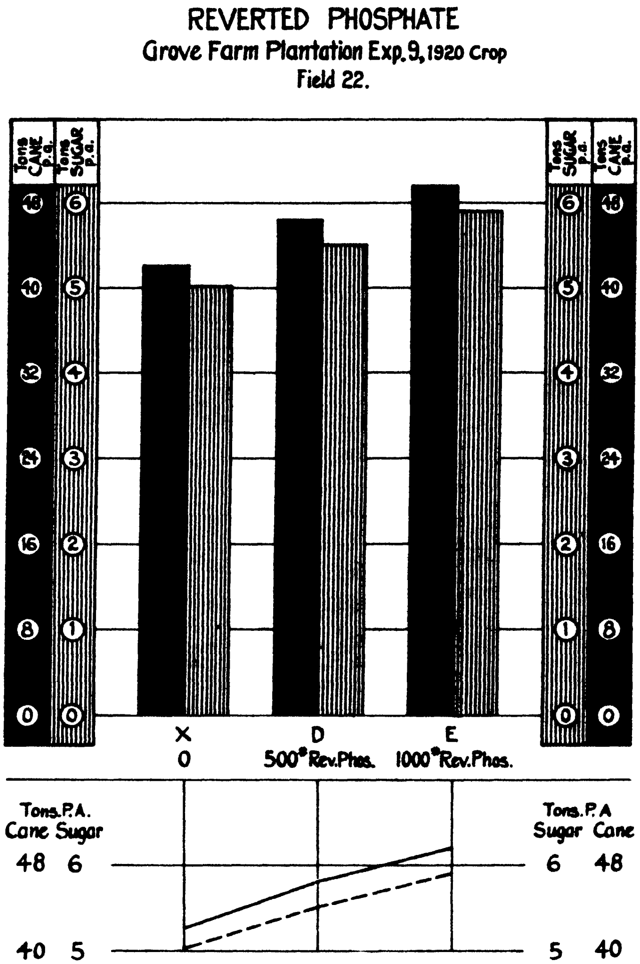
The field in which this experiment was conducted was virgin land. Comparisons were made between 0, 500, and 1000 pounds reverted phosphate per acre. The phosphate was applied broadcast after second plowing, harrowed in, and the field then furrowed and planted.

The response was immediate. When the cane was but six weeks old, marked differences were noted in favor of phosphoric acid. Not only in this particular area was the difference noted, but in the surrounding field the contrast between phosphate and no-phosphate areas was very marked. This difference was plainly discernible during the whole growth of the crop.

The application of 500 pounds reverted phosphate increased the yield by 4.34 tons cane, or 0.5 ton sugar, while 1000 pounds reverted phosphate increased the yield by 7.48 tons cane, or 0.89 ton sugar.

Fig. 2. 500 pounds reverted phosphate per acre.

The cane represented in the photographs above is Yellow Caledonia plant, in virgin land, not irrigated. The cane was planted at the same time and received identical treatment, except that that shown in Fig. 1 did not receive phosphate, while that in Fig. 2 received 500 pounds reverted per acre. (Grove Farm Exp. No. 9, 1920 crop.)



The following table shows the treatments and results:

Plot	Treatment	Tons Cane per Acre	Q. R.	Tons Sugar per Acre	Increase Over No P_2O_5	
					Tons Cane	Tons Sugar
X	0	42.14	8.39	5.02	0	0
D	500 lbs. R.P.	46.48	8.42	5.52	4.34	0.50
E	1000 lbs. R.P.	49.62	8.39	5.91	7.48	0.89

The addition of phosphoric acid has caused practically no difference in the juices, the analysis of which follows:

Plot	Lbs. Rev. Phosphate per Acre	Brix	Pol.	Purity	Q. R.
X	0	18.06	15.80	87.5	8.39
D	500	18.10	15.75	87.0	8.42
E	1000	18.17	15.85	87.2	8.39

DETAILED ACCOUNT.

Object: 1. To determine the value of reverted phosphate.
2. Amount to apply.

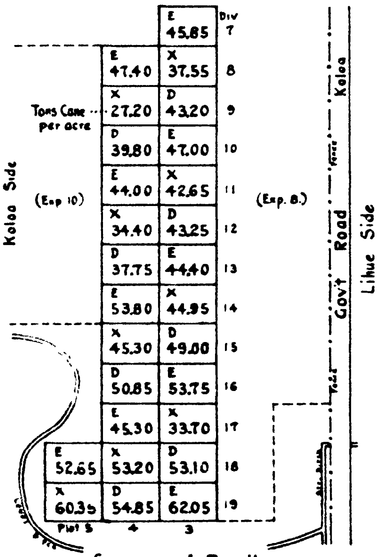
Location: Field 22.

Crop: Yellow Caledonia plant cane on virgin land.

Layout: No. of plots, 27.
Size of plots, 1/10 acre (60′ x 72.5′).

Plots are composed of 13 straight lines 4.7′ x 72.5′, and separated by 3-foot roadways running at right angles to the rows.

REVERTED PHOSPHATE
Grove Farm Plantation Exp. 9, 1920 Crop
Field 22.



Summary of Results

Plots	No. of Plot	Treatment	Yields Per Acre		
			Cane	Q.R.	Sugar
X	9	0	42.14	8.39	5.02
D	8	500# Rev. Phos.	46.48	8.42	5.52
E	10	1000# Rev. Phos.	49.62	8.39	5.91

Plan:

Plots	No. of Plots	Lbs. Rev. Phos. per Acre
X	9	0
D	8	500
E	10	1000

Phosphate applied broadcast and harrowed in.
Fertilization uniform to all plots.
Experiment planned and laid out by R. S. Thurston.

Progress:

May 22, 1918—Phosphate applied.
June, 1918—Furrowed and planted.
June 28, 1920—Experiment harvested by J. H. Midkiff.

R. S. T.

Fertilizer: Amounts to Apply.

Grove Farm Plantation Experiment 10 (1920 Crop).

This experiment is to determine the profitable limit of nitrogen applications on the mauka lands of Grove Farm lying on the slopes of Kilohana crater.

Comparison is made between 0, 100, and 200 pounds nitrogen per acre, applied in three equal doses in December, February, and June. The following tabulation shows the amounts of application and the yields:

Plot	No. of Plots	Lbs. Nitrogen per Acre	Yield, Tons Cane per Acre	Q. R.	Yield, Tons Sugar per Acre	Increase Over X	
						Tons Cane	Tons Sugar
G	12	0	38.79	8.93	4.34	0	0
H	12	100	42.86	9.07	4.73	4.07	0.39
I	12	200	41.91	9.18	4.57	3.12	0.23

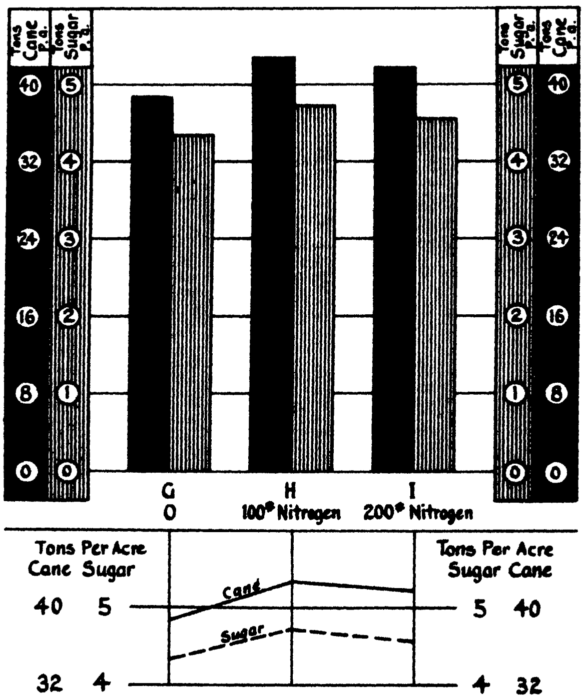
The application of 100 pounds nitrogen increased the yield 4.07 tons cane and 0.39 ton sugar, while 200 pounds nitrogen caused an increase of but 3.12 tons cane and 0.23 ton sugar over no nitrogen.

AMOUNT OF NITROGEN TO APPLY

In addition to nitrogen, all plots received 500# of Reverted Phosphate p.a.

Grove Farm Plantation Exp. 10, 1920 Crop

Field 22.



This experiment was conducted on soil deficient in phosphoric acid. When it was noted that this cane was suffering from a lack of phosphoric acid, a uniform dose of 500 pounds reverted phosphate was applied to all plots. This application caused an improvement in the cane, but it never recovered from the early setback. Had this experimental area received phosphoric acid early in the growing season, it is possible that the gains from nitrogen would have been more pronounced.

DETAILED ACCOUNT.

AMOUNT OF NITROGEN TO APPLY.

In addition to nitrogen, all plots received 500 pounds Reverted Phosphate per acre.

Grove Farm Plantation Exp. 10, 1920 Crop

Field 22.

Tons Cane p.a.

Plots	11	10	9	8	7	6	5	Div.
						H 34.45	G 32.40	8
						G 31.05	I 31.50	9
			I 40.45	H 35.75	G 34.00	I 42.15	H 36.00	10
	G 46.15	I 51.70	H 59.70	G 35.75	I 36.00	H 41.50	G 35.55	11
	I 54.55	H 54.10	G 53.70	I 42.45	H 40.20	G 41.40	I 40.70	12
	H 49.10	G 43.65	I 44.75	H 41.50	G 28.00	I 31.90	H 33.30	13
		I 43.65	H 49.50	G 47.30	I 43.10	H 39.20	G 36.55	14

Object: To determine the amount of nitrogen to apply on acid, virgin land.

Location: Field 22.

Crop: Yellow Caledonia plant cane.

Layout: No. of plots, 36.
Size of plots, 1/10 acre (60' x 72.5').

Plots are composed of 13 straight lines 4.7'x72.5', and separated by 3 foot roadways running at right angles to the furrows.

Summary of Results

Plots	No. of Plot	Treatment	Yields Per Acre		
			Cane	Q.R.	Sugar
G	12	0	38.79	8.93	4.34
H	12	100* Nitrogen	42.86	9.07	4.73
I	12	200* Nitrogen	41.91	9.18	4.57

Plan:

Plots	No. of Plots	Lbs. Nitrogen per Acre Applied			Total Lbs. Nitropen per Acre
		Nov., 1918	Feb., 1918	May, 1919	
G	12	0	0	0	0
H	12	33.33	33.33	33.33	100
I	12	66.66	66.66	66.66	200

Fertilizer—N.M.: 15% N. (6% nitrate, 6% sulfate, 3% organic).

Progress:

June, 1918—Experiment planted.

October 30, 1918—All plots given uniform dose of 500 pounds reverted phosphate.

December 19, 1918—First fertilization. Nitrate of soda used instead of nitrogen mixture. No note taken of slight difference in composition between N. M. and N. S.

February 5, 1919—Second fertilization, using nitrogen mixture.

June 6 and 7, 1919—Third fertilization, using nitrogen mixture.

June 28, 1920—Experiment harvested by J. H. Midkiff.

Experiment planned and laid out by R. S. Thurston.

R S T

Termites or White Ants in Sugar Cane.

By O. H. Swezey.

Another instance of termites attacking sugar cane has come to our notice. In a single stool of cane growing in his garden on Piikoi Street in Honolulu, Mr. E. L. Caum found in July of this year a few of the stalks much eaten and hollowed out by the termites, which had worked into the stool from below ground and on up into the stalks of cane. These termites had apparently reached the stool of cane from a nearby fence, which was badly infested with them.

Mr. Caum also found tubers of the edible canna, growing nearby, infested by these termites.

The only previous record of termites attacking growing cane in the Hawaiian Islands was in the case of five stools in a field of the Oahu Sugar Co., on the Waipio peninsula in Pearl Harbor, in July of 1917. An account of this occurrence is given in the *Planters' Record*, Vol. XVII, p. 113, September, 1917. Figures are given of the insects and the sugar cane eaten by them. At that time we did not know the species, though it closely resembled *Coptotermes gestroi* and *C. formosanus*. Since then, it has been given a name (*Coptotermes intrudens*) by Masamitsu Oshima, an entomologist of Formosa, to whom specimens had been sent. The description with figures is published in Proceedings of the Hawaiian Entomological Society, Vol. IV, No. 2, p. 261, June, 1920.

In March of this year this same termite was found to be working in sweet corn on Quarantine Island. It was noticed by Dr. Sweet, who called Mr. Ehrhorn's attention to it. When later investigated by Messrs. Ehrhorn and Williams and myself, it was found that a good many of the living well-grown stalks of corn had been entirely eaten out so that they fell over. The termites had eaten in from below the surface of the sandy soil and worked upwards the same as in the sugar cane noted above. A large pile of old lumber and timbers badly infested with the termites was near the garden, and there were runways in the sandy ground to the injured stalks of corn.

In this connection it should be mentioned that at the Experiment Station on Keeaumoku Street and Wilder Avenue, the fence is very badly eaten with the same termite in many places, and it is very remarkable that no work of the termites has ever yet been found in the sugar cane of any of the plots, even though within a few feet of the fence.

Sugar Refining in the Island of Cuba.*

By H. O. Neville.

The ever-increasing production of sugar in the Island of Cuba and the doubts that naturally arise with regard to the probability of marketing it in its crude state if European production expands and the production of beet sugar in the United States continues increasing, lend interest to the question of sugar refineries and the direct production in Cuba's mills of plantation white sugars. In the past only a very limited number of our mills have produced what are known as washed sugars which have gone into direct consumption in the Island. A few mills have established small capacity refineries at which a small percentage of their crude sugars has been purified, this production also going into the local market. But one large refinery has been established and is in continuous operation, this being the Cuban American Sugar Co.'s plant at Cárdenas. Also smaller plants have been established in connection with chocolate and cracker factories in Havana and others of our larger cities.

But, as we have indicated above, the continued increase in production of crude sugar in our factories and the knowledge that we must seek other markets than those of the United States for quite a considerable percentage of this production, in connection with the fact that in nearly all other markets, especially those of England and France, the demand is for refined sugar, has led a number of the leading men of our sugar industry to think seriously of the establishment in Cuba of refineries for purifying and preparing for the markets mentioned above that portion of our crop which it is believed can be disposed of to them. At the present time, a refinery of 3000 barrels daily capacity is being installed in connection with Central "Limones" by Sr. Lezama, the owner of the latter. A plan has also recently been suggested by Sr. Anibal Mesa to the Association of Hacendados and Colonos that a pool of $10,000,000 be formed among wealthy sugar men of the Island for the purpose of establishing at favorable coast points of the Island three first-class, up-to-date sugar refineries, these to be used as what might be considered a balance wheel for the sugar industry, being operated at times when difficulty in disposing readily of crude sugar occurs, and allowed to stand idle during those periods when the total production of crude sugar in the Island meets a ready demand. This proposal was submitted in the form of a letter to Sr. Miguel Arango, the President of the Association, and in his reply he indicated his conformity with the plan suggested and recommended that serious study be given it.

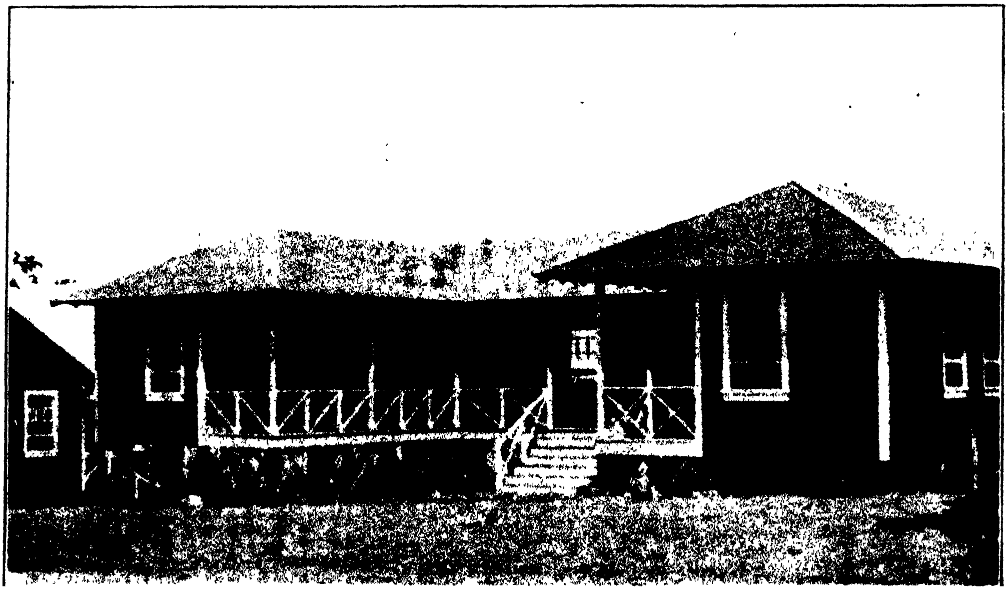
The utility of such refineries can readily be realized by all those who have been familiar with the heavy demand for refined sugars at almost any price that has been received in Cuba from the United States consumers during November and December of 1919 and to date this year. Millions of pounds of white sugar could readily have been disposed of at very remunerative prices, had these existed in the Island. [R. S. N.]

* The Cuban Review, June, 1920.

Examples of the Work of Plantation Improvement.

Industrial Service Bureau, H. S. P. A.

Illustrating improvements in mill yards.



Single men's club house situated on an Oahu plantation.

Showing old and new quarters on an Oahu plantation.

Two-family apartment house on an Oahu plantation.

Why Industry Seeks Competent Counsel.*

By L. V. Estes.†

There is, perhaps, no more distressing spectacle than to see a home into which sudden illness has come. The agitation and hurried moving around, the anxiety for the signs of the doctor's approach, the feverish consultation among the older people, all indicate the fears that are felt by the family and the hope that they have that the physician will be able to successfully cope with the malady. Every family on some occasion has had such an experience, and each one realizes, at such a time, that he is quite dependent on the doctor's skill and knowledge. No one except a very ignorant or bigoted person would refuse to call on competent outside counsel at such a moment.

The doctor's place in the community is now so well established, and the value of the services that he renders so evident, that the indispensability of his counsel in time of need is taken as a matter of course. No one would be so foolish as to try to prescribe for himself, for if a man who is his own lawyer has a fool for a client, the man who is his own doctor is very likely to have a corpse for a patient. It is recognized that the doctor is especially trained for the work that he has to do, and his standing in the community is established since his competency is attested by the state in which he practices.

The position of the surgeon is exactly analagous. If a broken bone is to be set, if a wound is to be sewed up, the person to whom we most naturally turn is the recognized surgeon. He brings to his task the training that he has received in both university and hospital, and out of his long experience he performs the delicate operation with the practical certainty that it will be a success.

The Consultant Is Recognized in the Business World.

When we turn to the business world, we find that the same thing is true in many instances. No group of business men would dream of trying to incorporate a new company without the assistance of a lawyer, and if the corporation is to be a large one from the start they will unquestionably secure the advice of some attorney who has made a specialty of the matter of incorporating new con-

* Portion of an Article from Industrial Management, June, 1920.

† From a wide professional experience the author has knit together the reasons why industrial firms seek and employ competent counsel. These reasons are reinforced by the view of the industrial engineer himself as to the advantage that his own counsel and advice may be to the management of a plant that is seeking for improvement and progress. Mr. Loring Vincent Estes became a machinist apprentice when eleven years old and then, successively, a journeyman and foreman of an erecting crew. At twenty-three he entered the United States Navy as second-class machinist; served his enlistment and then held the positions of civilian inspector and master machinist, the first in a private yard, the latter at the Philadelphia Navy Yard. Moving to California he became master machinist in construction and repair at the Mare Island Navy Yard, and under the direction of Mr. Holden A. Evans installed the first efficiency system ever put in a government machine shop. Returning later to the East he held several engineering positions, finally becoming superintendent of the Chicago branch of the Miller-Franklin & Stevenson Company. Afterward he purchased this Chicago business and established it as L. V. Estes, Inc., now one of the largest industrial engineering firms in the United States.—The Editors, Industrial Management.

cerns. Every company that is doing any considerable business consults legal counsel from time to time, some concerns regularly retain it, and a few even have lawyers on their own staff of officials. Even where there are attorneys on the board of directors, it frequently happens that some other lawyer is called in to give his advice, for it is realized that the outside point of view is valuable.

In recent years other classes of expert counsel in addition to lawyers have been called into being by the need that business has felt for them. The auditor who makes a periodic audit of the financial books of a company is now a well-recognized advisor to the business concern. As a result of the connection established by auditing financial books of the company, the business executive began to call on the auditor or public accountant for constructive help to correct the troubles which his audit often disclosed. Thus the expert accountant commenced his work and, though frequently he is at the same time an auditor, he has nevertheless a separate and distinct field of consulting service to offer to the individual business.

The Ever-widening Field of Action for the Competent Counselor.

These are just two of the many forms in which the advice and counsel of experts is made available for the use of the business executive. The list has grown by leaps and bounds in the past few years. Consulting engineers in the structural, mechanical, chemical branches, advertising experts, traffic experts, income-tax specialists, appraisers, are simply a few of the names taken as illustrations from such a list of consultants. Perhaps most important of all, and certainly most inclusive in the scope and effectiveness of the service rendered, is the industrial engineer.

With so many lines of consulting service developing, there must be some fundamental and underlying reasons for the increase. Individual consultants may come and go, but the extent to which they render their service is growing with astonishing rapidity. The reason must be in the value of the service rendered, as business men do not continue to pay out money if they do not get real returns for the expenditures that they make.

The Economy of Employing Outside Counsel.

One of the first reasons, then, for the existence of outside counsel is that it is directly and immediately economical from the business point of view. Small concerns cannot afford to maintain a large staff of highly-paid experts to give them the needed counsel on problems as they arise. Neither can a small concern afford to do without the counsel of experts, if it is to remain in the running, and especially if it is to grow from a little business to a big one. The availability of competent outside counsel solves this problem. He has all the knowledge and training that the expert permanently hired by the big company has, and at the same time it is necessary to pay for his services only when they are being actually used. He is available almost always on call, and when he is employed regularly he soon obtains a familiarity with the particular problems of the company in question that is almost as great as that of the expert who is constantly on the job with the company. The value of continued industrial consulting service cannot be overemphasized.

The Knowledge of Any One Man Is Limited.

As we look further, however, we see that the causes for this ever-increasing demand are far more fundamental and basic than the economy of a few dollars for the smaller concerns. "Ninety per cent of the progress of the world has been made in the last fifty years," said a well-informed man recently. And yet it would have been a rash man 50 years ago who would have claimed more than a very small part of all the knowledge that it was possible to possess. Even such a man as Herbert Spencer, whose grasp of many fields of science was perfectly astounding, whose natural intellect was prodigious, and whose training was unique in its breadth and depth, knew only a small part of all that there was to be known. No really great man has ever been heard to wish for new intellectual worlds to conquer as Alexander sighed for more kingdoms to bring under his sway.

If 90 per cent of the progress of the world in general has been made in the last 50 years, much more than 90 per cent of the progress in the business and industrial world has been made in that time, for business and industry have been the ones to profit most directly by the remarkable discoveries and inventions that have taken place in the material world. Electric motors, for example, have directly benefited the public, as electric fans, washing-machines, etc., have all done much to make life more livable, especially for the mother in the home, but they have helped the public far more through the indirect means of promoting industry. The telephone has facilitated social intercourse, but it has almost revolutionized in some respects modern commercial organization.

Progress Depends on Combining Intelligence.

If the business and the industrial world is considered from the economic point of view, the changes that have taken place have been even more remarkable, though we know that in large measure they are tied up with, and dependent on, the scientific development that has at bottom made them possible. The modern corporation 50 years ago was still in its infancy for the partnership, or personal way of doing business still sufficed for most of the needs of the day. Today, incorporation has fostered the growth of business to such a point that companies are sometimes top heavy, and in many cases their complexity is far beyond the ken of any one man.

This simply means that the intelligence and training of more than one man must be drawn on for the adequate direction of such large organizations as we now see in the industrial and commercial world. The day of the "one man" company has gone by, and the day of the combination of intelligence has come in. The most successful general manager is the one who fully realizes this and who does not try to do everything himself. If every detail must go through his hands for decision, action is very slow in taking place. His success lies rather in his ability to pick and choose the men who can do the things that he wants done, and who can supplement his lack of knowledge in fields where his training and experience have been incomplete. More and more it is being recognized that real greatness and true leadership lies in a keen appreciation of moral and intellectual values, and action based on such understanding rather than in the accumulation

of a mass of facts covering many fields and the possession of the blotting-paper type of mind that will permit the retention of such a conglomeration.

The "Doers" and the "Thinkers."

People may be divided into the "doers" and the "thinkers." This does not mean that the thinker never does anything or that the doers never think. Such an assumption is not at all warranted and is not implied. What is meant is, that some people are primarily occupied with the how and why of things—they are the thinkers, and the others with the when and where—the doers. That is, one group of people is occupied with getting things accomplished and the other group is taken up with the manner in which the accomplishment is brought about. Most of the people in any business organization are of the "doer" class, for the business world exists primarily for the accomplishment of tasks. The making and marketing of goods, with all that this involves, is the principal object of the business world.

The fact, however, that getting things done is the principal occupation of business does not mean at all that the other class of men have no place in the realm of industry but must be relegated to some classification of non-producers, or considered as purely ornamental. Getting things done, doing the same things over and over again, getting out production, is more or less of a tread-mill process when looked at from one point of view. By that it is meant that, just as in the tread-mill a certain amount of power which may be easily measured is delivered each day, and in that sense very definite results are accomplished, nevertheless the tread-mill stays fixed in one place and does not either move in position or increase in its ability to produce power. So in the case of the men who are the ones that make the daily output of the company, the ones who carry on the routine duties or who are occupied in directing them, what they accomplish while easily measured and definite in its benefits, yet nevertheless is not a means for the development of the company.

It is perfectly natural that this should be so and this statement is not intended in any way as a slight on the value of the work of the man who makes the wheels go round day after day. These men have their time and energy taken up in the immediate task of getting definite and tangible results, and they have neither the time nor the strength to allow them to think up new and improved ways of doing their work, to better produce, or discover the means to obtain increased gains or avoid losses.

Accomplishment Depends on the "Doers," Progress on the "Thinkers."

Nevertheless, if the company is not going to stagnate—and that signifies going backward if it does not go ahead—the means for making this progress must be found. Some companies, as has already been noted, keep their own staff of experts. They have a lawyer who devotes his entire time to their interests, they have their own auditors and accountants, as do the railroads, and now many large corporations have their own staffs of industrial engineers to improve the methods inside their factories. These are the thinkers, the men who must see to it their company is always abreast of the crowd, if not ahead of it. Even when

a company has its own staff of experts it sometimes finds it advantageous to call in the outsiders to help them.

A public service corporation that maintains its own appraised engineers recently engaged a consulting firm of appraisal engineers to make a separate and distinct survey of its entire property. This gave them not only a check on the work of their own engineers, but it provided them with a statement by which they were able to show that the rates for their service were not excessive.

Outside Counsel Must Be Competent.

However, outside counsel must be really competent or it is valueless. Poor advice is worse than none at all. The word "competent" has a very definite meaning. A man who is competent to do a certain thing is one who is fitted and prepared for the work which he undertakes to accomplish. He must be adequate and sufficient for the tasks that he takes upon himself. He should be capable of handling his duties in such a way as to accomplish them successfully, and he ought to be qualified to meet the problems that come his way. Too much emphasis cannot be laid on the necessity of the counsellor being thoroughly competent, for much of the opprobrium that is now attached to consulting service in some quarters is due to the fact that some consultants have been in no way fitted for their tasks. The man who is not properly qualified and equipped to render the service that he offers in a satisfactory manner which will lead to beneficial results for his client, is a menace both to those whom he professes to serve and to the profession of which he claims to be a member. None will be quicker to condemn the incompetent consultant than members of his profession who are adequately prepared for their tasks. Such an experience as the following will not overtake a man who is really competent.

Counsel That Was Not Competent.

The general manager of a large company, who is modern and progressive in his approach to the problems that come to him for solution, was not satisfied with the results that he was getting from his boilers. He had studied the matter somewhat himself and had had the chief engineer investigate the question, but still he felt that the greatest efficiency had not been obtained from the power plant. He sought the assistance of an expert in power plant construction and operation.

The expert came, and gravely and seriously studied the problem that was presented to him. He spent hours observing the methods of stoking, and made elaborate records of coal consumption and power output. He investigated the coal and he examined the stack. He then retired to an office and made complicated calculations, and at last made a report embodying certain recommendations.

"The trouble with your power plant," said he to the president, "is that it needs superheaters for the steam. With the installation of superheaters of the proper sort you will increase the efficiency of your power plant 30 per cent."

"Uh-huh," said the president, as a sad, wan smile played around his lips, "so you've been working here for three weeks around our power plant and you

have not discovered yet that we have had superheaters of the type you describe for over a year and a half."

The expert packed up his report and departed, a very much discomforted man. We do not know whether or not he learned his lesson that it is not a wise thing to try to rely on a bluff to carry him where he should have relied on careful study and thorough training, but we do know that if the president had not been a very wise man, as well as a very energetic executive, it would have been the last time that he ever would have called for the assistance of an expert.

What Competency Depends On.

Individual competency in any line of work depends on individual ability developed by training and experience. In no other way can the capacity for successfully accomplishing one's tasks be attained. Natural ability depends on the physical, mental, moral qualities that go to make up a man's character.

Robust physical health and a strong physique that will enable a man to endure hard work, hardship, mental strain, long-drawn-out periods of close application to confining tasks is a great asset for any kind of work. It does not mean that because a man does not have these things that he will not be able to succeed in the tasks that he has set before himself, but it does mean that he will win out under a handicap. Sometimes manual dexterity is also important. The time-study man must be able not only to handle a stop watch with ease, but he must have the ability to handle tools with speed and effectiveness that he may be able to give the man he is teaching a practical demonstration of what is to be done and the way to do it.

Intellect.

The competent counsellor in particular must have a good intellect, for he is primarily sought for what he knows and for his ability to get this information across to the other man. Hence, he must be quick to grasp the problems that come his way. He should be able to analyze them, and to select the essential and eliminate the non-essential. He ought to be able to discriminate between the good and the bad, the correct and the incorrect. What he has found and wishes to retain he should be able to record in a useful and usable form. Much of the progress of which this world is capable is not realized because the man who first finds some new way of doing something, who gets a new idea, who develops some unusual invention, does not record what he has found, discovered, or developed.

Moral Caliber.

Important as intellectual ability is, it is not so important as the moral stature of the man. True it is, in any occupation moral qualities, using that term in the largest sense, are desirable, and in varying degrees essential. In an expert consultant, however, they are the very basis of all that he does, for without them his ability to accomplish his task is gone. They are the very basis of confidence in his work and advice, and if that confidence is lost or destroyed his opportunity for service to clients is past. Integrity, truthfulness, patience, persistence,

energy, sympathy, are a few only of the qualities that competent counsel must be possessed of, if he hopes to attain success. The moral qualities in the more limited sense of the word, such as honor, integrity, fair-dealing, veracity, a sense of responsibility are the very foundation stones on which he builds, and without them there is no foundation that will sustain an enduring structure. More and more are the men who offer their service in a consulting capacity coming to realize this, and as time goes on the standards that they are setting for their professional ethics are being raised uninterruptedly.

Training.

Inherent natural ability remains potential and does not become available for real service till it has been trained. The consultant needs the best of training, and he is fortunate if he can begin at the bottom and build upward consistently. The instruction that a man receives in the preparatory school, the college, university and technical school furnishes him with the tools that he is going to want and gives elementary practice in how to use them. There are many men that do not have these advantages and are obliged to get their training in other ways, often while they are getting their experience. While this means a lot of hard work for them, they are not altogether to be pitied, for they have the opportunity to derive great advantages therefrom. They are far better able to coordinate the practical and the theoretical than their brothers who have been blessed —or cursed—by being members of families that could afford them all the educational advantages.

Experience.

Well-trained natural ability is not enough, however, to equip a man to be a counsellor. He must have had experience, or he will lack the power to make his trained intelligence of use. The so-called "practical" men are very often inclined to make fun of the theoretically-trained men, and say that he is useless when it comes to the test of actual performance. Some of this feeling is undoubtedly justified, but some of it is probably due to a touch of jealousy which they feel that they, too, have not had these advantages. The theoretical man is frequently inclined to look down on the man who has learned most of what he knows by actually doing it, sometimes taking an attitude that can easily be considered snobbish, and forgetting that the practical man puts into effect the theoretical man's knowledge. The real fact of the matter is that there is no good reason for either attitude, for theory and practice should go hand in hand. Before a man can wisely and successfully advise others he must have had both thorough training and wide practical experience, involving the actual doing of the things about which he is consulting.

Specialization and Coordination.

As was stated in a previous paragraph, it is impossible for any one man to know all that there is to know about all the different matters that affect business. Each consultant, while he should have a good general idea of the principles that guide the affairs of the business world, should also be a specialist in some one

particular part of the field. To make the best use of the wisdom of the counsellor it is desirable that the counsellors shall be coordinated and organized. This is the reason why the organizations of consultants that have grown up in the past few years have been so successful. They have taken the specialized knowledge of each member and united it to that of each and every other member. In this way they have provided support for every man in the organization, for he knows that his own lack of information when he gets outside his own particular field will be supplemented by the specialized knowledge of his colleagues.

The service that can be rendered to a client by such an organization is much greater than could be performed by each of the specialists working separately, for the efficiency of the service rendered is greatly increased. It is not necessary to go to several experts for desired advice, for all are grouped in one organization. All the records of the consultation provided will be kept in the main office of the consulting organization, and will be there available at any time for reference. No client need fear that valuable information will be disclosed, for it would be the height of professional indiscretion for a firm to give away its clients' secrets. At the same time the information of general interest that might be obtained by a consultant while working for a client would be put in a place where it would be at hand for the use of the other consultants, and not be lost because it is buried in the archives of a single concern. This makes the experience of one client available for the good of all, and each client can benefit from the accumulation of past experience made in this way.

Organized Consultants.

An organization of consultants is able to offer a client better service because it is able to maintain a research department which is constantly studying the difficult problems that come up and hence is ready to furnish any of the consultants information that they may need and have not had the opportunity of obtaining. This research department keeps in touch with all the latest books and periodicals, and through them it obtains the most up-to-date information that is published in regard to matters that may be germane to the work of any of the consultants. It also reviews the work of all of the experts to discover those things that they may have done which are original and which hold the possibility of being of value to the other members of the organization.

The Psychological Advantages of Outside Counsel.

The reasons why it is desirable to call in outside counsel are based on fundamentally sound psychological foundations. In the first place, the outside counsel brings to the problems that are confronting his clients an unbiased and unprejudiced viewpoint. He is not confused by having worked, with those problems always before him, till he is unable to obtain any but a distorted view of them. It is not intended by this to disparage in any way the attitude of the men who are daily doing the routine work. Prejudices are perfectly natural things to have. Habits are easy to acquire and are hard to lose. Habits—and prejudices are nothing more than likes and dislikes which are founded on certain

habits of thought—are one of the chief reasons why the man who does routine work can do it so expeditiously and well.

The very element of fixity in habit—that is, one of its virtues when work is looked at from the point of view of accomplishment of regular tasks—is a hindrance when it comes to the point of making changes and improvements. When betterments are to be made we need the kind of man who is always looking for something new, who has the quality of imagination, who is able to see beyond the present and behold in the future the accomplishment of that which he has conceived. The kind of man who is needed is the one who likes to go out into the unexplored regions of the earth, who likes to delve into the mysteries that science always holds before the investigator.

Keenness of Observation.

We all know that old expression which says that a new broom sweeps clean, especially as applied to the work of a new comer. This is perfectly true, for not only does an outsider come to the problem to be solved without the prejudices of long association with it, but he brings with him the freshness of viewpoint that is sensitive to all impressions. When we live along with a certain set of surroundings we become so accustomed to them that we are not aware of the details of which they are composed. It is the things that we come most in contact with that we observe the least. If you see a man look at his watch and then 30 seconds afterwards ask him what time it is, he is almost sure to look at his watch once more before he replies. Ask the same man to draw a rough sketch of his watch without looking at it, and when he has finished let the sketch be compared with the face of the watch and almost invariably there will be differences in essential details.

The same thing holds true in the business world. A particular method of filing may be out of date and difficult of operation, but it will still be used because no one in the organization has happened to see that it is obsolete. Steam pipes in the factory may be left exposed in places where the radiation is great and where the need for warmth is nil, and yet, because they have always been that way the master mechanic will pass them by unnoticed, though he would be the first to remark a similar condition in another factory that he might visit.

These are just two minor illustrations of a sort of thing that often happens with much larger matters. How often does it happen that a company allows its accounts receivable to run along month after month in such a way as to entail heavy drain on the profits, even if it does not wipe them out entirely, simply because they have become accustomed to it. Frequently a concern limps along with an imperfect organization or even none at all, and blames its lack of control of production, its failure to live up to promises of shipments, its meager profits, its trouble with its employees on the head of some one or few individuals when really the entire difficulty is due to the fact that the work is not so organized that even the best group of individuals in the world could accomplish it successfully.

Freshness of Viewpoint.

The outside counsel who comes in with the fresh, new point of view will be the first to see just these things. They will strike him vividly and at once, for even if he is familiar with the same kind of thing in other places, the surroundings will be so different that it will lose none of the freshness of newness as far as he is concerned.

The man from the outside will be able to get an entirely different view of the company and its problems than will anybody inside. He will have what is known as a perspective of the whole business, and perspective is one of the things that is most needed. If you ever saw a photograph of a twig taken at very close range and with nothing else near at hand with which you could compare the size, you probably had difficulty at first in telling whether it was really a twig or a branch. In other words, there was no perspective and means of comparison—the view was, in a way, distorted, for it did not give you a correct impression of what was actually represented.

The same thing is true in business, for the man who is constantly on the job at all times is frequently like the man who was so near the woods that he could only see the individual trees and could get no conception of the real size of the forest. In other words, he cannot grasp the whole of what he is looking at, for he is so close to it that he can see only the details.

Perspective.

The consulting engineer is in a position to get just these lacking perspectives or reviews. From his experience with many outside concerns he is able to correctly evaluate the status of the company that he is counselling. He can place it in its correct relation to the other business concerns in its class. The same thing is true in regard to what he finds inside the company, for it sometimes happens that matters which seem of small consequence because they have become habitual, when seen in their proper light and compared with similar conditions in other places, will be found to have an importance far beyond what was realized. For instance, overdue accounts receivable may be quite steady in the ratio that they bear to the total accounts receivable, and yet be far too high when compared with the same percentage among other concerns. The value of raw stores carried may not seem excessive to the managers till they find out that their competitors are doing business with much less of their capital tied up in this manner. A discovery of this kind can rarely be made by a man who is familiar with one company only.

It is obvious that the outside counsel will not know all the ins and outs of the particular concern he is called upon to aid. When a manager says that his business is different from every other business he is right to a certain extent. It is perfectly true that no other company has to meet exactly the same problems in the same form. Differences in location, differences in markets served, differences in the personalities that are at the head of them, and many other differences, all conspire to make the particular problems before any company just a little different from those of any other company. This fact has often served to deter the employment of outside counsel when really this fact should be one of the strongest reasons for calling on him for advice.

BREADTH OF EXPERIENCE.

The outside counsel brings with him the broad experience with many different concerns, some in the same line of business and some in others. He brings breadth and a knowledge of general principles and policies, experience with varying conditions and men that gives him more than the usual balance and poise and enables him to aid most effectively the men in the company who already have the details of the company's business at their finger-tips. What the general manager wants when he calls for outside counsel is not the acquaintance with detail that he naturally expects of those who are handling the routine work day by day, but the largeness of viewpoint which comes from handling many different projects. Hence the expert's lack of familiarity with details is an asset to the outside counsellor, for it enables him to retain his perspective, keep out of the ruts, and exert the influence of his prestige that comes with many successfully accomplished tasks. * * *

[R. S. N.]

Oils for Power Plants.*

By C. B. WHITMAN.†

Take a wine glass, dip your finger in water and as you rub it over the edge of the glass notice that the friction is pronounced; now wipe the finger dry and dip it in glycerin and again rub the glass—the friction is about the same. Dip the finger in lubricating oil and rub the glass. You find that the friction is almost imperceptible, which demonstrates that while glycerin has a viscosity far greater than the oil its lubricating quality is lacking, because the surface tension of either water or glycerin is not strong enough to form a substantial film, even under very light loads, for they are both lacking in capillarity and in molecular attraction. For this reason many very viscous liquids fail to form a good lubricating film.

This also demonstrates that to be a good lubricant a liquid must have nearly as great a surface tension as a solid, also that its lubricating value depends on the thickness of the layer it forms when spread over the surface and the resistance it offers to the efforts of the load to expel it from between the solid surfaces.

Little is known about the properties of liquid films other than that which is obtained from the frictional data. The static friction of solid surfaces when lubricated with lard oil and sperm oil prove that the lard oil gives the lowest coefficient and therefore must form the thickest film. Experience teaches that when the superfluous oil has drained away the combined capillary and molecular attraction comes to the aid of the viscosity and increases the tensile strength which tends to prevent rupture.

* From a paper read at Buffalo, N. Y. Pub. in "Power," July 6, 1920.
† Chief lubricating engineer, Sinclair Refining Co., New York Division.

Molecular and capillary attraction are possessed to a greater extent by mineral oils when properly refined, than by either animal or vegetable oils, but mineral oils are deficient in oiliness and will not keep the static friction as low as do animal or vegetable oils.

At speeds of 500 or more per min., under normal loads, and with bath lubrication, lard oil will sustain a film of only 0.005 in. thick, whereas a pure mineral oil of the proper viscosity will sustain a film of about 0.007 in. thick, which proves that for all ordinary machine bearings running under normal conditions, a mineral oil of the proper viscosity is a better lubricant by two-fifths than one of the best-known fixed oils. This has led to the blending and compounding of mineral oils. Blended oils are a mixture of mineral oil and fixed oils in proportions that will thoroughly neutralize; compounded oils are a mixture of mineral oil with metallic soaps of different kinds for the purpose of increasing the viscosity; experiment alone can tell as to the value of the mixture; often they are more detrimental than beneficial from a lubricating point of view.

As lubrication is of value only as its ability to reduce friction, we must consider the circumstances that influence friction. Cohesion is aggravated rather than diminished by efforts to produce smooth surfaces, for the more perfect the surface the greater will be the points of contact. At minute distances molecular attraction increases, which causes the surfaces to adhere and resist motion. For example, pieces of marble with polished surfaces will adhere when pressed together and their cohesion is so great that one piece when suspended will sustain the weight of the other. Again take two pieces of lead, scrape them clean and press them together in a vise and they will adhere almost as firmly as if they were one.

Of course the pressure to accomplish this is far greater than we get on a bearing, and I merely use these examples to show that there is cohesion between smooth surfaces. In a bearing the increased friction caused by motion generates heat, which increases the tendency of the surfaces to adhere, the area affected rapidly spreads and the surfaces seize or abrade each other. This happens in a "hot box."

The coefficient of friction of motion is the only one of interest from a lubricating point of view, and it is defined as that value which, when multiplied by the pressure normal to the surfaces in contact, gives the measure of the maximum frictional resistance to motion.

The value of viscosity and density of oils depends on the viscosity of the lubricant, the relative speed of the surfaces, their area and inclination to each other, thickness of the lubricating film. When these conditions are known, the resistance to the motion of any given body can be easily calculated.

To properly lubricate the different bearings found in modern practice, it is necessary for the lubricating engineer to know, first, the oiliness or greasiness of all lubricants, the frictional effects due to the viscosity of the lubricant, effects due to the different methods of application, the effects produced by different metals working in contact, the effects of temperature on friction and viscosity, and the effects due to different speeds under given loads. When the speed of the rubbing surfaces is less than ten feet per minute, the lubricant, instead of being forced between the surfaces and keeping them apart, is swept on under pressure, and the lubricant depends as much on its oiliness as on the viscosity.

Solid lubricants such as mica, graphite and soapstone have great carrying power at low speeds, but their value depends as much on the nature of the surfaces. Graphite, for instance, gives the best results when used on cast-iron surfaces, which are naturally very porous and hold the graphite, but the frictional loss and wear are great. Solid lubricants mixed with animal fats, greases, vaseline or rosin oil are suitable for low speeds and heavy loads, as they give a low coefficient and do not waste away rapidly by evaporation nor run off the bearings. Greases compounded from animal and vegetable fats, or mineral oils emulsified with water soap and alkali enough to neutralize them, are good lubricants for slow-moving bearings with excessive loads, provided the oils do not contain too much water and are not adulterated with foreign substances; the oil should not run down and leave the soap, which is liable to occur in poorly made greases.

Properties of Lubricating Oil for Low Speeds and Heavy Loads.

In selecting an oil for low speeds and heavy loads, viscosity is the first guide, and next is oiliness. At speeds of 100 ft. per min., with proper application, as before stated, the oil forms a fairly thick film, and when the load does not exceed 250 lb. per sq. in., the formation of the film and the friction are wholly due to the viscosity; but at heavy loads the bearing surfaces are brought into contact at a point on one side of the bearing and the lubricant should possess oiliness to a greater degree to prevent seizing. In cases of flat surfaces, such as the guide on reciprocating engines, the viscosity is not quite so important as the oiliness; at loads of 75 lb. per sq. in. a blended lubricant is best.

For motors, generators, turbines and the crankcase type of high-speed engines, best results are had by using a straight mineral oil of the proper viscosity. For motors and generators with bath-ring oiling devices best results are obtained by using a pure mineral oil of a viscosity of from 120 to 198 (Saybolt) according to speed and load. Turbines having either forced or circulating lubrication should have a light oil for two reasons: First, because the lighter oils maintain their viscosity better at the relative high temperatures, and second, on account of the high speeds. It must also be an oil that will not emulsify and one that will readily separate from water, as there is leakage of steam in most turbines. The viscosity should not be less than 98, nor more than 120 at 100 deg. F.

For steam-cylinder lubrication there are four conditions met with in modern practice that form a guide in selecting a proper oil; namely, steam supersaturated, saturated, dry, and superheated. For a supersaturated condition the oil should be heavily blended with pure tallow to give good results; for a saturated condition a light blend of tallow and blown rape will give good results; for dry steam about 6 per cent blown rape gives good results, but for superheated steam one must have a pure steam-refined mineral oil, otherwise the intense heat will burn off the animal and vegetable oil, release the acids they contain and pit the cylinder walls.

[W. E. S.]

Electrification of Mills.*

By Charles Griffith.

The main advantages of electric drive are not at first apparent. It does not appear that the machines can be more advantageously driven by electric motors which receive electric energy from an electric generator, which in turn is driven by a steam turbine, than by a steam engine direct.

A decrease in operating expense and an increase yield results from the use of economical direct motor-driven centrifugal pumps, the electrification of all mechanical drives and the decrease in the exhaust steam from the centralized power generating equipment.

When the output of a mill is to be increased by equipment of greater capacity, it will be found that this can be accomplished at a minimum cost by the coincident substitution of electric drive. Also the capacity of the sugar apparatus of a mill can be increased by the change over to electric drive. To obtain the maximum benefits, however, it is usually necessary to make some slight changes in the sugar apparatus to balance the capacity of the several stations. The saving in operating expense and the increased yield pay for the cost of changing over an existing mill in two or three years.

When a new mill is considered, there are additional reasons for adopting electric drive. The motor-driven machinery costs less, it can be more advantageously placed, it is smaller and lighter and costs less to install.

Practical Tests.

The new mills in Cuba, and those that have been changed over to electric drive, have demonstrated the reliability, economy, and superiority of the electric drive.

Rare is the steam-driven mill in which the bagasse is sufficient to evaporate the juice, and which also gives a fair yield. The consumption of fuel in addition to that furnished by the bagasse has been found to be productive of increased profits in a well-designed steam-driven mill. This fuel is required to evaporate the maceration water. The economical proportion of maceration water, and hence the additional fuel, is dependent upon the market price of sugar and the cost of the coal or wood used.

On the other hand, in a well-designed electrically-driven mill, the bagasse is more than sufficient to evaporate the normal juice and the maximum effective degree of maceration water can be applied, which results in a high yield. The bagasse becomes sufficient, due to the reduction of the total power required, the

* Facts About Sugar, July 17, 1920. A reprint with slight condensations of an original contribution to the South African Sugar Journal for April, 1920.

decrease in the amount of steam required per horse power of work, the smaller radiation and leakage losses, and the increased efficiency of the heating, evaporating and cooking apparatus.

It has been demonstrated that power can be generated from a large steam turbine and transformed through an electric generator, transmitted to motors, and transformed to mechanical work at the driven machine more efficiently than by a large number of small steam engines and steam pumps.

The adoption of the electric motor permitting the use of high speed centrifugal pumps tends toward a smaller amount of power required for pumping.

Saving in Steam Requirements.

The amount of steam required to produce the same amount of useful work is materially reduced, mainly by the generation of power from a large steam turbine instead of in a large number of small steam cylinders. The amount of steam required per horse power in a steam cylinder operating by throttle control or non-expansively between the limits of pressure common in sugar mills will range from 75 to 100 pounds, whereas the amount required by a Curtis steam turbine operating expansively between the same pressures will be half of the lower figure. This amount can be further reduced by higher steam pressures and super heat to which the steam turbine is eminently suited, but which is detrimental to the operation of the steam engine.

A detailed study of a mill producing 179 tons of sugar per day discloses the fact that electrification would remove 7500 square feet of high and low pressure piping serving steam pumps and engines. Conservative estimates of the radiation losses showed that the loss of heat from this cause alone accounted for 20 per cent of the fuel bill.

The labor item in a mill constitutes the greatest proportion of the manufacturing cost. In normal times it ranged from 4 to 10 per cent of the total cost of the sugar, depending upon the country. The great increase in wages during the last few years makes the reduction of the manufacturing force very desirable.

The reduction in the number of attendants by electrification is apparent. A detailed study was made in a steam-driven mill of the number of operators and repair men which would be affected by a change over to electric drive. After computing the wages paid chargeable to the steam engines and pumps and determining the attendants known to be required with electric motor drive, it was found that the electrically-driven plant would reduce the manufacturing and maintenance labor £8 per day. This mill was producing 1,100 bags of sugar, of 325 lbs. each, per day. This results in a reduction of a shilling per ton of sugar. The force would be reduced by 26 men. This reduction also effects a reduction in the clerical force in the general office.

Reduction of Supplies.

The reduction of the supplies in a mill by electrification is a very strong argument in favor of the adoption of electric motor drive. Lubricating oil and pump and engine piston packings are big items of expense. The electric motor and

centrifugal pump consisting of only revolving elements mounted in oil ring type bearings require a very small amount of oil.

The pump packings surrounding the rotating shafts last a long time. The steam turbines and generators in the power house have similar oiling systems and likewise require very little oil.

In the steam-driven mill the lubricating oil runs from the bearings or is carried off by the exhaust steam and becomes a source of trouble, either by collecting on the engine, pump or floor, or being carried into the steam heating coils and calandria. In an electrically-driven mill, however, the oil returns to the oil wells of the pump and motor bearings, and is again carried up on to the shafts and thus used over and over again. No oil is used inside the turbine, so that the exhaust steam is entirely free from oil.

The oil, grease, packing, waste, pipe coverings, soda, re-agents and replacement of worn-out parts in a steam-driven mill average 2s. 4d. (56.77 cents) per ton of sugar. Of this amount a saving of at least one-third is effected by electric drive.

Continuity of Service.

Continuity of service in a sugar mill is of the utmost importance as affecting manufacture. It is customary to operate the mill to the utmost capacity during the harvesting of the crop. Any shutdown period reduces the amount of cane ground, and as the labor expenses and fixed charges go on, the cost of manufacture is thereby increased. Electric drive has won the reputation of being the most reliable means of power application.

There are many cases of continuous operation of electric motors for periods of several years without a shutdown due to the electric system. The majority of interruptions in a cane sugar mill are from slipping of the rolls and repairs necessary to the steam engines and steam pumps.

Engines frequently stop on dead center or at the end of the stroke, and time is consumed in getting started after repairs or adjustments have been made. The shutdown periods of mills from slipping can be practically eliminated by electric motor drive through the indications of the power meters of the individual motors. By a readjustment of the relative speeds of adjacent sets of rolls, the rolls can be made to take their proper division of the load, and slipping is prevented.

Cheaper Water Supply.

A supply of pure fresh water is required at all mills. This water is usually obtained from a nearby stream or well, and must be pumped to the mill. The distance from the mill makes it necessary with a steam-driven mill to provide a boiler plant with the necessary attendant. The small size power plant, and the constant services of an attendant bring the unit cost of water delivered to the mill to a high figure. The unit cost of water at an electrically-driven mill, on the other hand, is low owing to the decreased costs of pumping. No boiler plant is required at the pumping station, as the electric power can be transmitted over a transmission line from the mill.

The electric drive of repair shops is attended with similar economies. While machine shops are commonly located in the mill building, carpenter shops are usually in a separate building and have their own boiler plants. The saving in fuel and labor is difficult of determination, as they are run so irregularly.

The fuel consumed by the machine shop will be less with electric than with steam drive, due to the higher efficiency of the higher power united in the main power house. It may be assumed that the carpenter shop operates from waste wood, but a fireman is necessary for the boiler.

In Repair Shops.

The electric drive is particularly of advantage in repair shops where the operating periods are irregular. The tools can be started up at any time without waiting for steam or for an engine to warm up. Where the tools are individually motor-driven, power and hence fuel are consumed only while they are in operation. Tools can be located at points most convenient for their use.

In stating the benefits of electric drive an attempt has been made to place a money value on the savings. This is possible of quite accurate determination in the case of fuel, labor, supplies, and repairs. But for increased yield, shutdowns, and pumping of supply water, certain assumptions must be made. For other items, such as repair shops, transport and administration, local conditions vary so widely that it is not feasible to evaluate the expense or savings. These must be determined from a study of the individual mill.

The savings from the definitely determined items are so great that the decision to electrify can be made on these alone. Moreover, these figures have been taken from data collected on a conservative and impartial basis. Details have been given as far as is possible in so brief an article, so that a mill owner can compute the figures applying to his own mill.

Figures from Cuban Practice.

Below is a table summarizing the various items on a basis of the average Cuban mill producing 102 tons of sugar per day, or a total of 15,900 tons in a crop of 156 days. The aggregate savings are considerable and will pay for the cost of changing over an existing mill in a very short time. If only the interest on the added investment is considered, the net saving per year increases the net profits by a large amount. The market value of a mill is increased by a greater amount than the cost of the improvements. (*Note.*—In reprinting the table the figures given by Mr. Griffith have been converted from British to United States values.—Ed., "Facts About Sugar."

	Steam	Electric	Saving
Fuel (additional to bagasse)	$12,093	$.....	$12,093
Labor (manufacturing)	43,526	40,046	3,480
Supplies	9,022	5,961	3,061
Repairs	27,569	26,118	1,451
Shutdowns (labor)	598	......	598
Water supply and miscellaneous	2,311	......	2,311
			$22.994
Increased yield (maceration)			32,240
Total reduction per year			$55,234
Reduced cost per ton sugar			$3.41

[R. S. N.]

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Losses Caused by Delay in Harvesting Burned Cane.

EWA PLANTATION, FIELD 3A, 1920 CROP, H 109, 1ST RATOONS, LONG.

By J. A. VERRET.

DESCRIPTION OF EXPERIMENT.

The primary object of this experiment was to determine the losses which take place when handling cane from large accidental or incendiary fires. In some of these large fires, it sometimes takes from ten days to two weeks before all the burned cane is harvested. It was desired to learn not only the total loss in sugar, but also to find out the loss in weight of cane.

For this purpose a level, uniform section of slightly over three acres was selected at Ewa plantation, in Field 3A. The cane was H 109, first ratoons, long. The field had been recently irrigated, and the soil was still moist when the experiment was started. No rain fell during the period of the experiment.

The area selected consisted of four water courses, each containing 144 full lines and a few hapas. (See map giving the layout, page 242.)

The cane in the third and fourth water courses, blocks 2 and 3, was burned standing. The second water course was used as a fire break, while the cane in the first was unburned to serve as a check, indicating whether any changes were taking place in the quality of the juices not caused by burning.

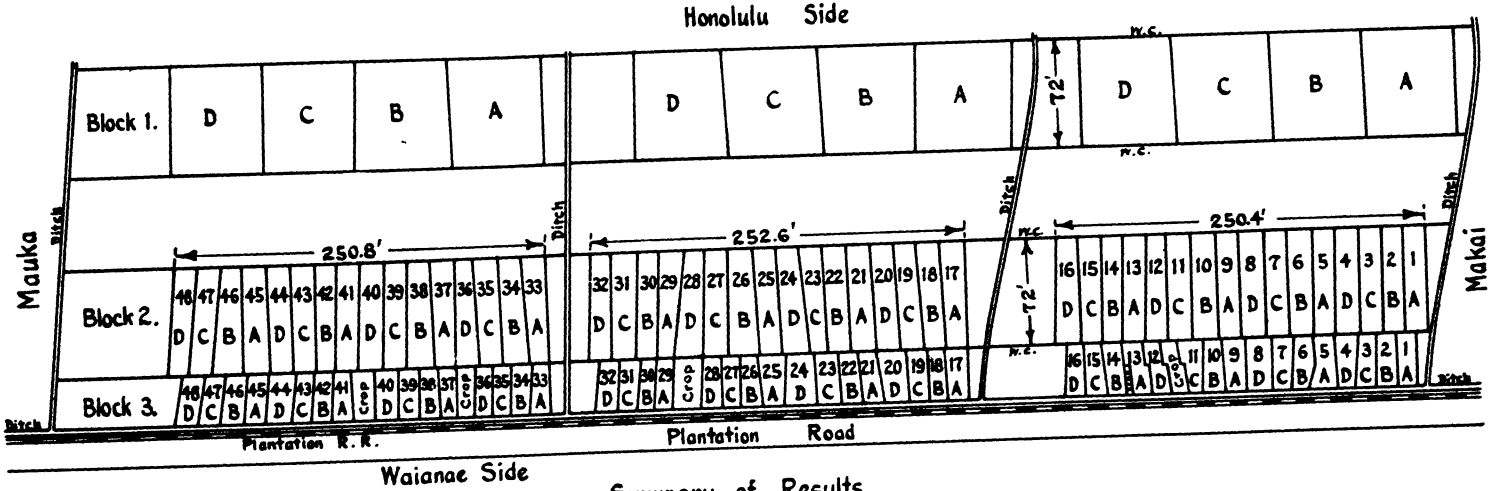
Burned blocks 2 and 3 were divided into 48 plots each. The plots were numbered from 1 to 48, and divided into four series, A, B, C and D, of 12 plots each. The A plots were harvested immediately after burning, the B plots 5 days, the C plots 10 days, and the D plots 15 days after. Whenever burned cane was harvested, corresponding areas of unburned cane from block 1 (first water course) were also harvested.

After the field was harvested all plots were surveyed, and the actual area of each determined.

Blocks 2 and 3 were burned between 4 and 6 a. m., July 26, 1920. All the cane in block 3 was then immediately cut and allowed to lie on the ground until harvested. The cane in block 2 was allowed to stand until harvested.

Loss in Weight of Cane and Sugar for Varying Periods After Burning.

Miscellaneous Experiment 36. (Ewa Plantation Co. Field 3A.)



Summary of Results.

Block No. 1.
(Unburned)

Plots	No. of Plots	Date of harvesting.	Yields Per Acre Cane	Q.R.	Sugar
A	3	JULY 27, 1920.	86.36	8.18	10.56
B	3	JULY 31, 1920.	92.88	8.36	11.11
C	3	AUG. 5, 1920.	88.40	8.33	10.61
D	3	AUG. 10, 1920.	84.79	8.39	10.13

Block No. 2.
(Burned July 26, 1920 & left standing.)

Plots	No. of Plots	Date of harvesting.	Yields Per Acre Cane	Q.R.	Sugar
A	12	JULY 26, 1920.	87.20	8.24	10.58
B	12	JULY 31, 1920.	81.45	9.14	8.91
C	12	AUG. 5, 1920.	77.25	10.28	7.51
D	12	AUG. 10, 1920.	68.97	13.57	5.08

Block No. 3.
(Burned and cut July 26, 1920.)

Plots	No. of Plots	Date of harvesting.	Yields Per Acre Cane	Q.R.	Sugar
A	12	JULY 26, 1920.	87.25	8.39	10.40
B	12	JULY 31, 1920.	73.90	8.18	9.03
C	12	AUG. 5, 1920.	67.66	9.22	7.34
D	12	AUG. 10, 1920.	61.79	11.60	5.33

On July 26 all the A plots in blocks 2 and 3 were harvested, the cane loaded and the juices sampled. It was not possible to finish in one day, so the A plots in the unburned block were harvested and sampled on July 27. On July 31 all the B plots were harvested. The C plots were harvested on August 5th, and the D plots on August 10th.

DETAILED RESULTS.

In the following tables are given the weight of cane, the juice analyses, and the tons of cane and sugar per acre for each plot:

BLOCK 1.—UNBURNED CANE CUT AND WEIGHED AND SAMPLED JULY 27, 1920.

Plots	Weight of Cane	Juices*				Tons per Acre	
		Brix.	Pol.	Pur.	Q. R.	Cane	Sugar
1 — A1	6175						
1 — A1	5918	19.2	16.50	85.9	8.11	85.96	10.60
1 — A1	5785						
2 — A1	6250						
2 — A1	5550	19.4	16.73	86.2	7.99	83.22	10.41
2 — A1	5930						
3 — A1	5940						
3 — A1	6280	18.2	15.74	86.5	8.49	89.89	10.58
3 — A1	6480						
	Average...	18.9	16.32	86.3	8.18	86.36	10.56

BLOCK 2.—CANE BURNED AND CUT JULY 26; WEIGHED AND SAMPLED JULY 26, 1920.

Plots	Weight of Cane	Brix.	Pol.	Pur.	Q. R.	Cane	Sugar
1 — A2	(weight lost)	19.2	16.72	87.1	7.96	...	....
5 — A2	4660	18.5	16.09	87.0	8.26	89.8	10.87
9 — A2	5320	19.7	17.32	87.9	7.64	99.0	12.96
13 — A2	4115	19.6	17.10	87.2	7.77	79.3	10.20
17 — A2	4650	19.1	16.70	87.4	7.94	89.6	11.28
21 — A2	4700	18.8	16.27	86.5	8.18	90.5	11.07
25 — A2	4525	19.0	16.58	87.3	7.99	87.2	10.91
29 — A2	4745	18.8	16.37	87.1	8.11	91.4	11.27
33 — A2	4320	18.9	15.51	82.0	8.84	83.2	9.41
37 — A2	4190	18.3	15.15	82.8	8.99	80.7	8.98
41 — A2	4275	18.7	15.77	84.3	8.53	79.1	9.27
45 — A2	4640	18.2	15.18	83.4	8.93	89.4	10.00
	Average...	18.9	16.23	85.9	8.25	87.2	10.57

* All juices are crusher samples. A continuous sample was taken of each car as it went through the mill.

BLOCK 3.—CANE BURNED AND CUT ON JULY 26, 1920; WEIGHED AND SAMPLED JULY 26.

1 — A3	2840	19.6	17.22	87.9	7.69	103.7	13.48
5 — A3	....	18.6	16.19	87.0	8.20	...	....
9 — A3	2300	18.6	16.02	86.1	8.36	83.9	10.04
13 — A3	2485	18.8	16.12	85.6	8.32	90.7	10.90
17 — A3	2650	18.6	16.19	87.1	8.20	96.7	11.80
21 — A3	2260	18.7	16.00	85.6	8.38	82.5	9.84
25 — A3	2790	18.5	15.88	85.8	8.42	76.4	9.07
29 — A3	2255	18.1	15.18	83.9	8.90	82.3	9.25
33 — A3	2440	19.1	16.55	86.6	8.04	89.0	11.08
37 — A3	2430	18.1	15.35	84.8	8.75	88.7	10.13
41 — A3	2435	18.4	15.64	85.0	8.61	88.9	10.32
45 — A3	2110	18.1	15.10	83.4	8.98	77.0	8.58
	Average...	18.6	15.95	85.8	8.37	87.25	10.41

BLOCK 1.—UNBURNED, CUT, WEIGHED AND SAMPLED JULY 31, 1920.

Plots	Weight of Cane	Juices				Tons per Acre	
		Brix	Pol.	Pur.	Q. R.	Cane	Sugar
1 — B1	4140	17.9	15.64	87.4	8.49		
1 — B1	4760	17.6	15.13	86.0	8.84		
1 — B1	5170	18.9	15.87	84.0	8.51	103.17	12.04
1 — B1	7180	18.3	15.81	86.4	8.44		
2 — B1	4750	19.0	16.45	86.6	8.10		
2 — B1	4505	18.8	16.53	87.9	8.01		
2 — B1	4220	18.8	16.19	86.1	8.25	82.73	10.12
2 — B1	4150	18.6	16.04	86.2	8.35		
3 — B1	3190	18.5	16.14	87.2	8.25		
3 — B1	4315	18.3	15.59	85.2	8.63		
3 — B1	4295	18.4	15.95	86.8	8.35	92.72	11.10
3 — B1	7000	18.7	16.24	86.8	8.21		
	Average...	18.5	15.96	86.3	8.37	92.88	11.11

BLOCK 2.—BURNED AND LEFT STANDING JULY 26; CUT, WEIGHED AND SAMPLED JULY 31.

2 — B2	4150	18.6	15.49	83.3	8.77	79.9	9.12
6 — B2	4460	17.9	14.77	83.6	9.19	85.9	9.35
10 — B2	4630	19.2	15.85	82.5	8.63	89.2	10.33
14 — B2	3920	18.6	15.59	83.8	8.68	75.5	8.70
18 — B2	4465	18.6	15.66	84.2	8.65	86.0	9.94
22 — B2	4025	18.4	15.12	82.2	9.06	73.9	8.16
26 — B2	5270	18.5	14.79	80.0	9.40	89.9	9.56
30 — B2	4625	18.3	14.91	81.9	9.21	84.2	9.14
34 — B2	4510	18.3	15.04	82.2	9.12	81.0	8.88
38 — B2	4870	18.1	14.21	79.1	9.85	86.6	8.79
42 — B2	3880	18.6	14.93	80.3	9.28	74.7	8.05
46 — B2	4400	18.3	14.67	80.2	9.47	70.5	7.45
	Average...	18.6	15.09	81.1	9.15	81.45	8.96

BLOCK 3.—BURNED AND CUT JULY 26; WEIGHED AND SAMPLED JULY 31, 1920.

2 — B3	....	20.9	17.49	83.7	7.76	...	...
6 — B3	....	20.6	17.36	84.2	7.78	...	...
10 — B3	1730	19.9	16.20	81.4	8.51	63.1	7.42
14 — B3	1930	19.7	16.11	81.8	8.53	70.4	8.26
18 — B3	2160	19.9	16.49	82.9	8.25	78.8	9.55
22 — B3	2290	20.0	16.35	81.8	8.41	83.6	9.94
26 — B3	2200	19.6	15.82	80.7	8.73	80.3	9.20
30 — B3	1740	20.3	16.72	82.3	8.18	63.5	7.76
34 — B3	2110	20.6	17.39	84.4	7.76	77.0	9.92
38 — B3	2000	20.4	17.18	84.2	7.88	73.0	9.26
42 — B3	2000	20.6	17.15	83.3	7.93	73.0	9.20
46 — B3	2090	19.5	15.90	80.1	8.71	76.3	8.76
	Average...	20.2	16.68	82.6	8.18	73.90	9.03

BLOCK 1.—CANE UNBURNED; CUT AND SAMPLED AUGUST 5, 1920.

Plots	Weight of Cane	Juices				Tons per Acre	
		Brix	Pol.	Pur.	Q. R.	Cane	Sugar
1 — C1	5160	18.1	15.59	86.1	8.58		
1 — C1	3970	18.1	15.64	86.4	8.54		
1 — C1	4445	18.4	16.14	87.7	8.21	87.39	10.49
1 — C1	4865	18.8	16.58	88.2	7.98		
2 — C1	4750	18.9	16.53	87.5	8.04		
2 — C1	4050	18.9	16.70	88.4	7.90		
2 — C1	4275	19.1	16.92	88.6	7.80	84.13	10.61
2 — C1	4250	19.1	16.96	88.8	7.77		
3 — C1	3215	17.5	14.80	84.6	9.13		
3 — C1	2625	17.9	15.43	86.2	8.67		
3 — C1	6620	17.7	15.16	85.7	8.84	93.67	10.53
3 — C1	6555	17.4	14.97	86.0	8.95		
	Average...	18.3	15.95	87.1	8.33	88.40	10.61

BLOCK 2.—CANE BURNED JULY 26; CUT AND SAMPLED AUGUST 5, 1920.

3 — C2	4240	18.1	13.97	77.2	10.16	78.5	7.73
7 — C2	4310	18.2	14.11	77.5	10.05	79.7	7.93
11 — C2	4330	18.1	14.11	77.9	10.03	79.7	7.95
15 — C2	3280	18.4	14.13	76.8	10.09	63.2	6.26
19 — C2	4020	17.9	13.56	75.8	10.60	77.4	7.30
23 — C2	4200	19.1	14.34	75.1	10.07	80.9	8.03
27 — C2	4580	18.6	14.13	76.0	10.15	84.8	8.36
31 — C2	4770	17.6	13.12	74.5	11.08	85.7	7.73
35 — C2	4120	18.1	12.94	71.5	11.52	79.4	6.89
39 — C2	4160	18.1	13.29	73.4	11.04	80.1	7.26
43 — C2	3740	18.8	13.89	73.9	10.50	68.8	6.56
47 — C2	3565	22.0	16.32	74.2	8.91	68.7	7.71
	Average...	18.6	14.00	75.3	10.28	77.25	7.51

BLOCK 3.—CANE BURNED AND CUT JULY 26, 1920; LOADED AND SAMPLED AUGUST 5, 1920.

3 — C3	....		Sample	lost		...	...
7 — C3	....	21.8	16.72	76.7	8.50	...	...
11 — C3	2060	20.8	15.77	75.8	9.10	75.2	8.26
15 — C3	1940	21.2	15.79	74.5	9.19	70.8	7.70
19 — C3	2320	20.7	15.41	74.4	9.43	84.7	8.98
23 — C3	2350	21.5	16.02	74.5	9.07	64.3	7.09
27 — C3	1770	20.9	15.99	76.5	8.93	64.6	7.24
31 — C3	1780	21.3	15.92	74.7	9.08	48.7	5.37
35 — C3	1760	20.7	15.42	74.5	9.43	64.2	6.81
39 — C3	1855	21.0	15.62	74.4	9.30	67.6	7.27
43 — C3	1780	20.1	14.68	73.0	10.02	65.0	6.48
47 — C3	1960	20.6	15.19	73.7	9.61	71.5	7.44
	Average...	21.0	15.69	74.7	9.22	67.66	7.34

BLOCK 1.—UNBURNED CANE; CUT AND SAMPLED AUGUST 10, 1920.

Plots	Weight of Cane	Juices				Tons per Acre	
		Brix	Pol.	Pur.	Q. R.	Cane	Sugar
1 — D1	4115	17.7	15.15	85.6	8.84		
1 — D1	4645	17.4	15.16	87.1	8.77		
1 — D1	3925	17.8	15.43	86.7	8.64	85.04	9.83
1 — D1	5090	17.9	15.81	88.3	8.35		
2 — D1	4075	18.0	15.91	88.4	8.28		
2 — D1	4420	18.4	16.24	88.2	8.18		
2 — D1	4540	18.9	16.53	87.4	8.03	85.60	10.53
2 — D1	4425	18.9	16.50	87.3	8.04		
3 — D1	3745	18.4	15.83	86.0	8.44		
3 — D1	4540	18.7	16.04	85.8	8.34		
3 — D1	4450	18.0	15.62	86.8	8.53	83.72	9.90
3 — D1	4510	17.6	15.51	88.1	8.52		
	Average...	18.1	15.81	87.4	8.39	84.79	10.13

BLOCK 2.—CANE BURNED JULY 26; CUT AND SAMPLED AUGUST 10, 1920.

4 — D2	3320	18.0	11.18	65.6	14.15	63.9	4.52
8 — D2	4240	18.3	12.17	66.5	12.85	81.7	6.36
12 — D2	3290	18.2	12.55	69.0	12.15	61.4	5.05
16 — D2	3530	18.4	12.65	68.8	12.10	65.0	5.37
20 — D2	4970	18.1	11.83	65.4	13.40	91.9	6.86
24 — D2	3965	18.3	11.85	64.8	13.90	75.2	5.41
28 — D2	4340	18.1	12.15	67.1	12.80	77.2	6.03
32 — D2	3805	17.4	11.41	65.6	13.87	73.3	5.28
36 — D2	3130	17.8	11.29	63.4	14.40	54.5	3.79
40 — D2	3280	17.7	11.17	63.2	14.58	63.2	4.33
44 — D2	3310	17.5	11.20	64.0	14.40	63.8	4.43
48 — D2	2940	18.9	11.54	61.1	14.53	56.6	3.90
	Average...	18.1	11.75	64.9	13.57	68.97	5.08

BLOCK 3.—CANE BURNED AND CUT JULY 26; LOADED AND SAMPLED AUGUST 10, 1920.

4 — D3	....	22.5	14.85	66.0	10.63	...	...
8 — D3	2310	22.8	15.10	66.2	10.42	63.2	6.07
12 — D3	1680	21.4	13.90	65.0	11.48	61.3	5.34
16 — D3	1700	22.4	13.69	61.1	12.26	62.1	5.06
20 — D3	2460	22.6	13.76	60.8	12.24	63.0	5.14
24 — D3	2480	21.1	13.95	66.1	11.30	54.3	4.81
28 — D3	1610	23.0	14.52	63.1	11.24	58.8	5.23
32 — D3	1930	21.1	13.05	62.0	12.67	70.4	5.56
36 — D3	1460		Sample	lost		53.3	4.59
40 — D3	1860		"	"		67.9	5.85
44 — D3	2210	22.1	13.90	62.9	11.77	60.5	5.14
48 — D3	1715	22.1	13.42	60.7	12.58	62.6	4.98
	Average...	22.1	14.01	63.4	11.60	61.79	5.33

NOTE:—In plots 2, 3, 4, 5, 6 and 7 of block No. 3, the lines were not straight, and the cane was so tangled that it was not possible to separate the cane accurately. For that reason the cane weights from these plots were not obtained.

The results obtained are summarized as follows:

Treatment	Time Since Burning	Yields per Acre		% Loss in Weight of Cane	% Loss in Sugar	Crusher Juice			
		Cane	Sugar			Brix	Pol.	Pur.	Q. R.
Block 1	Unburned	86.4*	10.54	....	....	18.9	16.32	86.3	8.18
" 2†	0 day	87.2	10.57	....	....	18.9	16.23	85.9	8.25
" 3†	0 day	87.3	10.41	....	....	18.6	15.95	85.8	8.37
Block 1	Unburned	92.9*	11.09	....	....	18.5	15.96	86.3	8.36
" 2	5th day	81.5	8.96	6.57	15.23	18.6	15.09	81.1	9.13
" 3	5th day	73.9	8.93	15.30	14.22	20.2	16.68	82.6	8.18
Block 1	Unburned	88.4*	10.55	....	....	18.3	15.95	87.1	8.34
" 2	10th day	77.3	7.48	11.39	29.23	18.6	14.00	75.3	10.30
" 3	10th day	67.7	7.26	22.45	30.26	21.0	15.69	74.7	9.23
Block 1	Unburned	84.8*	10.09	....	....	18.1	15.81	87.4	8.39
" 2	15th day	69.0	5.11	20.89	51.66	18.1	11.75	64.9	13.64
" 3	15th day	61.8	5.33	29.18	48.80	22.1	14.01	63.4	11.60

† Block 2 = Cane burned and allowed to stand until harvested.
Block 3 = Cane burned and cut at once, and allowed to lie on field until harvested.
* 5% off for trash.

In the following two tables are given the per cent. losses in weight of cane, and of sugar from burned cane for each day during fifteen days. The figures between harvesting dates are based on interpolations. The figures actually obtained are given in heavy type in the tables.

PER CENT LOSS IN WEIGHT OF CANE AFTER BURNING.

Days since burning	1	2	3	4	5	6	7	8
Left standing	1.31	2.63	3.94	5.26	6.57	7.53	8.50	9.46
Cut at once	3.06	6.12	9.18	12.24	15.30	16.73	18.16	19.59
Days since burning	9	10	11	12	13	14	15	
Left standing	10.43	11.39	13.17	14.95	16.73	18.51	20.29	
Cut at once	21.02	22.45	23.80	25.14	26.49	27.83	29.18	

PER CENT LOSS IN SUGAR FROM BURNED CANE.

Days since burning	1	2	3	4	5	6	7	8
Left standing	3.05	6.09	9.14	12.18	15.23	18.03	20.83	23.63
Cut at once	2.84	5.69	8.53	11.38	14.22	17.43	20.64	23.84
Days since burning	9	10	11	12	13	14	15	
Left standing	26.43	29.23	33.72	38.20	42.69	47.17	51.66	
Cut at once	27.05	30.26	33.97	37.68	41.38	45.09	48.80	

NOTE:—The losses in sugar given for the first and second days, based on interpolations, are unquestionably high. We plan a detailed study of this as opportunity offers. In work last year on unburned cane Verret and McAllep found the loss to be a little less than 3% at the end of two days. See table, page 251.

Discussion of Results.

The experimental error involved in this test is small. We were fortunate in obtaining a very uniform area for the experiment. The weather conditions during the test were such that no appreciable changes took place in the cane, as indicated by the juices of the unburned cane. That the area involved was very uniform is shown by the fact that the yields obtained the first day from Blocks 1, 2 and 3 were practically identical. The average yield obtained from the unburned cane harvested during the fifteen days of the test was 88.10 tons of cane, and 10.57 tons of sugar per acre, a close check with the yields obtained from all the plots the first day. The average juice from the unburned cane for the total period was 8.31 quality ratio, as compared with 8.27 quality ratio of all the juices from the first day's harvest.

Losses Due to Fire.

The figures given in the preceding paragraphs also show, in this case, when the cane is harvested within a few hours after the fire, that there was no loss due to burning; that is, the heat generated by the fire destroyed a quantity of sugar so small, if any, that it could not be detected. A few hours' delay in getting the cane to the mill causes a greater loss.

Losses Due to Delay in Harvesting After Burning.

The most striking thing about these losses are the losses themselves. They

are enormous. The average production of sugar for all the plantations on these Islands is about 0.2 ton of sugar per acre per month. The irrigated plantations produce about 0.26 ton. In this test the loss in sugar was at the rate of about $3\frac{1}{3}$% a day. Taking an average yield of 5 tons of sugar per acre, the loss would be 0.17 ton of sugar per acre per day for each day's delay in harvesting. In other words, each day's delay in getting the cane to the mill, after it is burned, represents a loss of 25 growing days.

When burned cane was allowed to stand, it was found that at the end of 5 days it had lost 6.57% of its weight, and 15.23% of its sugar, while, if cut immediately after burning, and left on the field, the loss in weight of cane at the end of 5 days was 15.30%, and the loss in sugar 14.22%. At the end of ten days the losses were 11.39% of cane and 29.23% of sugar for standing cane, and 22.45% of cane and 30.26% of sugar for the cut cane. In 15 days these losses

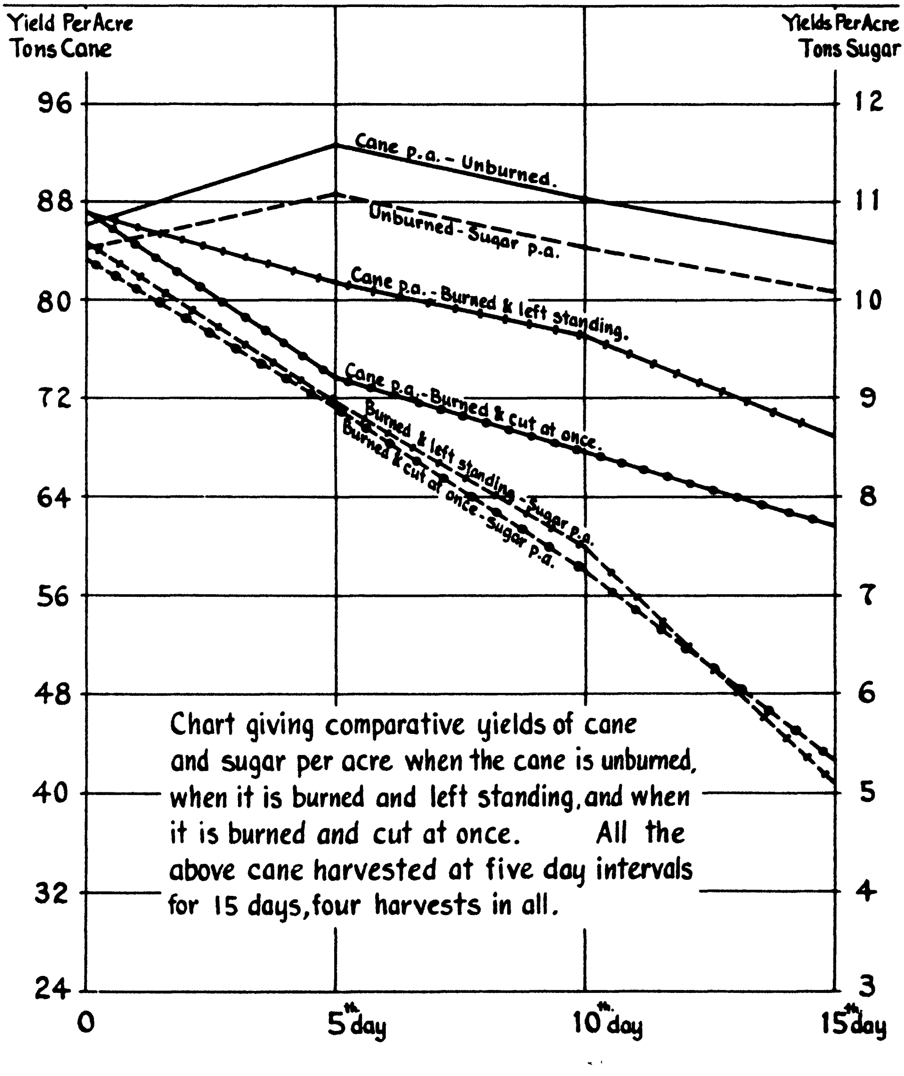
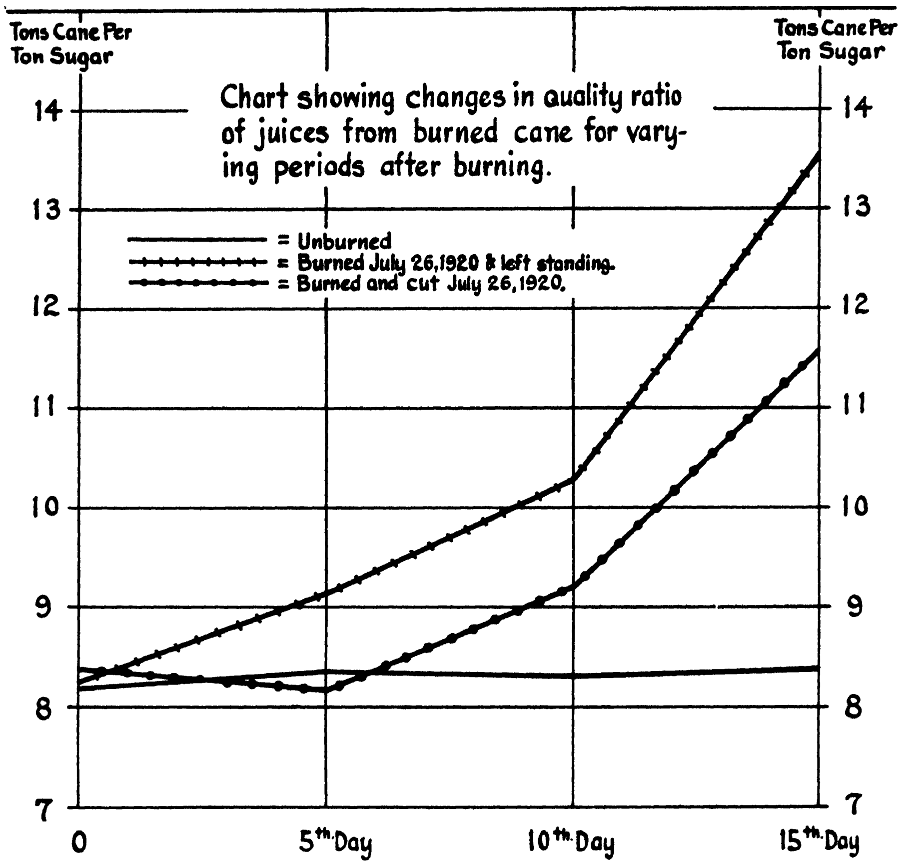


Chart giving comparative yields of cane and sugar per acre when the cane is unburned, when it is burned and left standing, and when it is burned and cut at once. All the above cane harvested at five day intervals for 15 days, four harvests in all.



were 20.89% cane, and 51.66% sugar, and 29.18% of cane, and 48.80% sugar, respectively.

It is rather striking to find from these results that after the cane was once burned it made no appreciable difference in the losses of sugar whether the cane was cut or allowed to stand. In either case the losses in sugar were about the same. This is shown graphically in the chart on page 249.

The cut cane lost more in weight of cane, but had a better quality ratio, due to a higher Brix. The density of the juice from the cut cane increased from 18.6 Brix on the 1st day to 22.1 on the 15th day, while that of the standing cane dropped from 18.9 Brix on the 1st day to 18.1 on the 15th day. The purities of the juices dropped at the same rate in both cases.

It follows from these results that if the cane is once burned, there is apparently nothing to gain by slowing up the cutting, so as not to get ahead of the loaders. From the field point of view, it would be an advantage to cut, in that there would be less weight of cane to handle to obtain the same amount of sugar. As against this it was found in the laboratory that the juices from the cut cane were harder to handle. The solutions for polarization filtered very slowly, and would not give clear filtrates. Small samples of juice were clarified to neutrality in beakers with lime and boiled. The juices from the standing cane settled in ten minutes, while those from the cut cane took thirty minutes to settle.

It is of interest to compare these results, obtained from burned cane, when working with carload lots under field conditions, with the results obtained by McAllep and Verret last year when working with small bundles of unburned cane.*

Taking the same variety, H 109, we have the following comparisons:

PER CENT LOSS IN WEIGHT OF CANE.

Days since cutting	1	2	3	4	5	6	7	8
Not Burned	2.8	4.0	5.9	7.4	9.5	9.9	12.1	13.0
Burned	3.06	6.12	9.18	12.24	15.30	16.73	18.16	19.59

The losses in weight are here found to be much more for the burned cane. This is explained by the fact that the cells in the burned cane were ruptured and broken down by the heat of the fire, and the water was more easily evaporated.

The per cent losses in sugar in the two tests are compared in the following table:

THE PER CENT LOSS IN SUGAR OF CUT UNBURNED CANE, CUT BURNED CANE, AND STANDING BURNED CANE.

Days since burning or cutting	1	2	3	4	5	6	7	8	9	10
Unburned, cut	1.4	**2.8**	7.5	**12 2**	15.1	**18.0**	26.4	**34.9**		
Burned, left standing	3.05	6.09	9.14	12.18	**15.23**	18.03	20.83	23.63	26.43	**29.23**
Burned, cut at once	2.84	5.69	8.53	11.38	**14.22**	17.43	20.64	23.84	27.05	**30.26**

In the above table the figures in heavy type were actually obtained; the others are interpolations. We believe that an actual determination would show the interpolated losses given in the table from the burned cane for the first and second day to be high. There is a remarkable agreement in the losses actually found for 4th, 5th and 6th day in tests conducted at different times under different conditions.

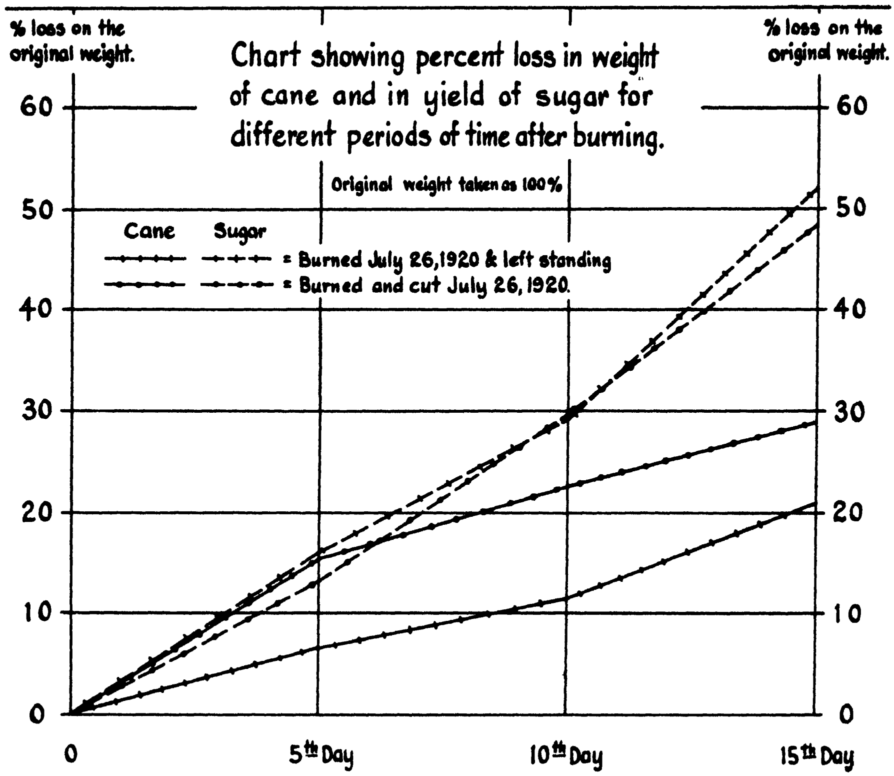
Summary.

1. Burned cane lost 50.23% of its original sugar when harvesting was delayed 15 days after burning, or at the rate of 3.35% per day. During the first five days the total loss was 14.72%, or at the rate of 2.94% per day. In ten days the loss was 29.74%, or 2.97% per day. The rate of deterioration shows a gradual increase as the time since burning increased.

2. There is very little difference in the losses in sugar between burned cane cut at once, and burned cane allowed to stand until milled.

3. When burned cane was allowed to stand, the loss in weight of cane at the end of five days amounted to 6.57%, or 1.32% per day. In 10 days the loss was 11.39%, or 1.14% per day, and in 15 days the loss was 20.29%, or 1.35% per day.

* Planters' Record, Vol. XXI, No. 3, page 145.



4. When burned cane was cut immediately after the fire, the loss in weight of cane was 15.30% in 5 days, or 3.06% per day. In 10 days the loss was 22.45%, or 2.25% per day, and in 15 days the loss in weight was 29.18%, or 1.95% per day. As was to be expected, the rate of loss in cut burned cane tends to diminish as the cane becomes drier.

5. When burned cane is allowed to stand, the density of the juice does not increase. The tendency was towards a slight decrease.

6. When burned cane is cut at once there is a decided increase in the density of the juice, in this case, from 18.6 to 22.1 Brix in 15 days.

7. The juices of burned cane, whether cut or standing, drop in purity at about the same rate.

8. The quality ratio (tons of cane per ton of sugar) of cut burned cane is better than that of standing burned cane. This is due entirely to a higher density of the juice from the cut cane.*

* All the juices were sampled and analyzed by Dr. Norris and Mr. Bomonti.

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Use of Water in Irrigation.
Samuel Fortier; McGrew-Hill Book Co., 239 W. 39th St., N. Y.

Farmers of Forty Centuries.
F. H. King; Mrs. F. H. King, Madison, Wis.

Power and the Plow.
L. W. Ellis and E. A. Rumely; Doubleday, Page & Co., New York.

Physics of Agriculture.
F. H. King; The Author, Madison, Wis.

Feeds and Feeding.
W. A. Henry; The Author, Madison, Wis.

The Diseases of Animals.
Nelson S. Mayo; The Macmillan Co., N. Y.

Fertilizers and Crops.
L. L. Van Slyke; Orange Judd Co., N. Y.

Fertilizers and Manures.
A. D. Hall; John Murray, London.

Insecticides, Fungicides, and Weedkillers.
E. Bourcart; Scott, Greenwood & Son, London.

The Book of the Rothamsted Experiments.
Sir A. D. Hall; John Murray, London.

Soil Conditions and Plant Growth.
E. J. Russell; Longmans, Green & Co., London.

Botany for Agricultural Students.
J. N. Martin; John Wiley & Sons, N. Y.

Bacteria in Relation to Country Life.
J. G. Lipman; The Macmillan Co., N. Y.

Diseases of Economic Plants.
F. L. Stevens and J. G. Hall; The Macmillan Co., N. Y.

Green Manures and Manuring in the Tropics.
P. de Sornay; John Bale, Sons and Danielsson, Ltd., London.

A Handbook of Tropical Gardening and Planting.
H. F. Macmillan; H. W. Cave & Co., Amen Corner, Colombo.

The Principles of Agriculture.
L. H. Bailey, Editor; The Macmillan Co., N. Y.

The Soil.
F. H. King; The Macmillan Co., N. Y.

The Fertility of the Land.
I. P. Roberts; The Macmillan Co., N. Y.

Irrigation and Drainage.
F. H. King; The Macmillan Co., N. Y.

The Feeding of Animals.
W. H. Jordan; The Macmillan Co., N. Y.

The Care of Animals.
Nelson S. Mayo; The Macmillan Co., N. Y.

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* Exhibited at the Short Course for Plantation Men, October, 1920.

Soil Fertility and Permanent Agriculture.
Cyril G. Hopkins; Ginn & Co., Boston.
Soils.
E. W. Hilgard; The Macmillan Co., N. Y.
A Handbook of Sugar Analysis.
C. A. Browne; John Wiley & Sons, N. Y.
Heat Conservation in Cane Sugar Factories.
R. Renton Hind; The Hawaiian Gazette Co., Honolulu, T. H.
Methods of Chemical Control for Cane Sugar Factories.
Hawaiian Chemists' Assn.; The Hawaiian Gazette Co., Honolulu, T. H.
A Handbook for Cane Sugar Manufacturers and Their Chemists.
G. L. Spencer; John Wiley & Sons, N. Y.
A Manual of the Steam Engine (Part I, Part II).
R. H. Thurston; John Wiley & Sons, N. Y.
A Manual of Steam Boilers.
R. H. Thurston; John Wiley & Sons, N. Y.
Steam Turbines.
J. A. Moyer; John Wiley & Sons, N. Y.
The World's Cane Sugar Industry, Past and Present.
H. C. Prinsen Geerligs; Norman Rodger, Manchester.
Cane Sugar and Its Manufacture.
H. C. Prinsen Geerligs; Norman Rodger, Manchester.
Something About Sugar.
G. M. Rolph; John J. Newbegin, San Francisco.
Cane Sugar.
Noel Deerr; Norman Rodger, Manchester.
Economic Entomology.
J. B. Smith; J. B. Lippincott Co., Philadelphia, Pa.
Agricultural Entomology.
H. Osborn; Lea & Febiger, Philadelphia and N. Y.
Manual for the Study of Insects.
J. H. and A. B. Comstock; Comstock Pub. Co., Ithaca, N. Y.
Half Hours with Insects.
A. S. Packard, Jr.; Estes & Lauriat, Boston.
American Insects.
V. L. Kellogg; Henry Holt & Co., N. Y.
Principles of Chemistry.
J. H. Hildebrand; The Macmillan Co., N. Y.
Agricultural Geology.
F. V. Emerson; John Wiley & Sons, N. Y.
An Introduction to Geology.
W. B. Scott; The Macmillan Co., N. Y.
Military Geology and Topography.
H. E. Gregory, Editor; Yale University Press, New Haven, Conn.
The Earth, Its Life and Death.
Alphonse Berget; G. P. Putnam's Sons, N. Y.
Natural History of Hawaii.
W. A. Bryan; The Hawaiian Gazette Co., Ltd., Honolulu.
Hawaii and Its Volcanoes.
C. H. Hitchcock; The Hawaiian Gazette Co., Ltd., Honolulu.
The Origin of the Earth.
T. C. Chamberlin; The University of Chicago Press, Chicago.
Elementary Meteorology.
W. M. Davis; Ginn & Co., Boston.

Kavangire: Porto Rico's Mosaic Disease-Resisting Cane.*

Something of Its History and Behavior in the Argentine.

By Arthur H. Rosenfeld, M. S.[1]

That "one half of the world does not know what the other half is doing" is an aphorism which had its birth many hundred years before the epoch of scientific agricultural investigation and publications, and which cannot be applied to the scientific world today. In the sugar cane world, particularly, we have of late years had many examples of a discovery or conclusion arrived at in one country being of equal or much more far-reaching value in others, the success of the Demerara 74 seedling cane in Louisiana and of the Java 36 and 213 seedling canes in Argentina being cases in point. Naturally the obtaining of these canes in Demerara or in Java did not signify *per se* that they would be superior to the canes in use at that time in Argentina, but the facility of international scientific exchange and the availability of publications referring to experimental work in all parts of the world made the securing of these varieties for trial in competition with hundreds of others in their new homes an easy and interesting affair.

Prof. C. O. Townsend, of the United States Department of Agriculture, has recently called attention in "Science"[2] to an interesting example of how experimental work in one country may result in far-reaching importance to the principal industry of another many thousands of miles removed. Several years ago an extremely serious sugar cane disease made its appearance in Porto Rico and, on account of its characteristic spotting of the leaves, came to be known as the *mottling or mosaic disease*. In many respects it appears to be identical with the well-known yellow-stripe disease so common in Java, and Dr. C. W. Edgerton has recently published an interesting article in the "Louisiana Planter" showing that it exists quite commonly in Louisiana, although its ravages would appear to be less pronounced there than in Porto Rico. When the seriousness of the new disease in the island was fully appreciated, the Porto Rican authorities requested the cooperation of the United States Department of Agriculture with their own insular and federal experiment stations, and Prof. F. S. Earle, of the Office of Sugar Plant Investigation of the Bureau of Plant Industries, was detailed in 1918 to take up this cooperative work.

"Among other lines of investigation Professor Earle studied very closely the sugar cane varieties growing in Porto Rico. He noted that among about twenty varieties growing at the Federal Station at Mayaguez there was one Japanese variety (Kavangire) which showed no sign of the mottling disease, while all the other varieties were more or less seriously affected. In order to carry this study further Professor Earle inaugurated an experiment with ninety varieties of cane on Santa Rite Estate. * * * Single rows of cane were planted of the varieties to be tested, and every third row was planted with the diseased seed of the

* International Sugar Journal, 1920, Vol. 22, pp. 26-33.
[1] Ex-Director of the Tucumân Sugar Experiment Station, Argentina.
[2] "An Immune Variety of Sugar Cane." May 16, 1919.

Rayada variety (ribbon cane). In this way each variety was uniformly and completely exposed to the infection.

"The first planting of the ninety varieties was made on October 1, 1918. Two and one-half months later all of the varieties except Kavangire showed the mottling disease, the infection running from 9 per cent to 96 per cent. This variety has remained free from disease to date, March, 1919, and shows every indication thus far of being immune to the mottling disease.

"On January 29 of this year, Professor Earle made a careful study of the experiment and found about half of the other varieties in the experiment showing infection of fully 100 per cent, and only in two cases was it as low as 50 per cent. The degree of infection, however, was decidedly marked in the different varieties, with the exception of the Kavangire, which appears to be entirely immune. Professor Earle has observed that Kavangire fully matured on the Federal Station at Mayaguez, and in other localities in Porto Rico where it is growing, it is entirely free from the mottling disease whether the plants are young shoots or mature canes."

A Brief History of This Cane in Argentina.

This cane figured amongst the first varieties to be tried out at the Tucumán Sugar Experiment Station, it being planted with two hundred other varieties in 1910, and showing from the first germination remarkable vigor, dark color, high agricultural production, fair juice if left for late cropping, and extreme resistance to fungous disease such as Rind Disease and Red Rot and attacks of boring insects such as *Diatraea saccharalis*. It was obtained from a lot of varieties under trial at the National Agricultural School in Tucumán, which had in turn obtained these varieties from the Experiment Station in Campinas, Brazil.

It was at once recognized that in this case we were treating with a misnomer, as the labels had evidently been mixed either in Brazil or in the Agricultural School at Tucumán, and *Kavangire* was merely a layman's attempt to spell Cavengerie, to which cane the one under discussion bears absolutely no relation, being a typical Japanese bamboo type of cane, identical with the Uba variety of Natal, whereas the Cavengerie is a large, soft, red cane with faint black stripes. In 1886 Dr. Alvarez Reynoso, of Havana, Cuba, sent to Dr. W. C. Stubbs, Director of the Sugar Experiment Station in Audubon Park, Louisiana, 27 canes of Cavengerie weighing 186 lbs., or about seven pounds per stalk.[1] These weights in themselves prove that there is no similarity between the Cavengerie cane and the thin, Japanese bamboo type of cane, which in our experiments in Tucumán gave an average weight of stalk for many years of just 490 grms., or just a little over one pound avoirdupois.[2]

Not being able to classify the cane exactly, although it appeared identical with the Uba and similar to the Zwinga, being apparently of better average sugar content than the latter, we continued our experiments with the variety under the name of Kavangire, and it was under this name that we sent a consignment

[1] "Sugar Cane." Issued by the Louisiana State Bureau of Agriculture and Irrigation, page 61. An early and interesting discussion of varieties.

[2] Rosenfeld, Arthur H., "Revista Industrial y Agricola de Tucumán." Vol. III, page 122, August, 1912.

of this cane to Prof. D. W. May, Director of the Federal Experiment Station at Mayaguez, Porto Rico, some time after publishing a description of it and other promising canes under trial in Tucumán in the "International Sugar Journal" of January, 1914.[3]

It is interesting to note that this article is the only one published in English in regard to this cane up to the time of the recent articles of Earle, Townsend, and Edgerton.[4] In it the author gives the results of two years of experimentation with the Kavangire in comparison with the native striped and purple canes (Cheribon), comprising one crop each of plant and stubble. In view of the importance which this cane has now assumed, a review of its behavior in the crops of 1911 and 1912 will not be out of place. Table 1 gives the results obtained in these crops in succinct form.

TABLE 1.—YIELDS AND ANALYSES OF KAVANGIRE AND NATIVE CANES.

I.—AVERAGE OF NATIVE STRIPED AND PURPLE.

Age	Met. Tons Cane per Hectare	Av. Weight Stalks, Grms.	Chemical Analysis					Kgs. Sugar per Hect.[6]
			Brix.	Sucrose	Glucose	Purity	Mfg. Value[5]	
Plant, 1911..	27.206[7]	570[8]	16.3	13.6	0.4	83.7	11.44	2201
Stubble, 1912.	30.080	750	16.2	13.7	0.5	84.3	11.52	2417
Average	28.643	660	16.3	13.7	0.4	84.0	11.48	2309

II.—KAVANGIRE.

Age	Met. Tons Cane per Hectare	Av. Weight Stalks, Grms.	Brix.	Sucrose	Glucose	Purity	Mfg. Value	Kgs. Sugar per Hect.
Plant	43.490	340	15.9	11.6	0.8	73.0	8.47	2579
Stubble	108.630	630	14.8	12.5	0.5	84.5	10.56	8030
Average	76.060	490	15.4	12.1	0.6	78.6	9.52	5305

A glance at this table shows that as plant, while giving 16 tons of cane more per hectare than the native canes, the chemical analysis of the Kavangire juice was far inferior to that of the native canes, the commercial or manufacturing value being about three points lower. Hence the yield of sugar per hectare was only about a third of a ton more than that of the native canes, this being obtained, naturally, at greater expense in the factory, due to its low industrial yield, but at very much reduced cost in the field, due to much cheaper cultivation: the Kavangire being an extremely rapid grower and shading the middles quickly. As stubble, however, the Kavangire almost tripled its agricultural yield, and, with

[3] *Idem*, "The most Promising Varieties of Sugar Cane under Trial at the Tucumán Experiment Station." Vol. XVI, No. 1, pages 12-23.

[4] *Loc. cit.*

[5] Obtained by multiplying per cent sucrose by purity. A practicable factor for average juices in Tucumán, likely to indicate too low a probable yield for juices below 70 purity and rather too high a one for juices above 80 purity.

[6] Calculated on a basis of 70 per cent extraction of juice on weight cane.

[7] 242,320 lbs. to the acre.

[8] 1¼ lbs.

almost as good juices as the splendid ones of the native canes, more than tripled its yield of sugar per hectare of the previous crop, giving us more than five and a half tons of sugar above the yield of the native canes under identical conditions! The average yield for the two years was almost three times as much cane, and well over twice the amount of sugar per hectare.

For the three following years, i. e., the crops of 1913, 1914 and 1915, the yields of cane per hectare of stubble of these plantations were as shown in Table 2. If we bear in mind that the Kavangire cost only about 50 per cent as much per acre in cultivation as did the slowly-growing native canes, the cost of production per ton becomes about 15 per cent of that of the native cane.

TABLE 2.—YIELDS OF CANE PER HECTARE AS SECOND, THIRD, AND FOURTH-YEAR STUBBLE.

Crop	Metric Tons (2207 Lbs.)		Advantage in Favor of Kavangire, Per Cent
	Native	Kavangire	
1913	26 55	112.21	Over 400
1914	17 40	70.70	" 400
1915	14.80	88.00	" 600
Average....	19.58*	90.30	Over 450

The behavior of this cane, then, in comparison with that of the native striped (the native purple, being next to this Japanese type of cane in the experiments, had been so shaded by the latter that the yield cropped to almost nothing in 1914 and 1915, hence we had to make our comparisons with its more favored companion) during five years from one planting can be graphically appreciated by studying Table 3.

TABLE 3.—AVERAGE YIELDS FOR FIVE YEARS.

Variety	Met. Tons Cane per Hectare	Av. Weight Stalks, Grms.	Chemical Analysis					Kgs. Sugar per Hectare
			Brix.	Sucrose	Glucose	Purity	Mfg. Value	
Native striped	23.149	650	17.0	14.8	0.3	87.1	12.9	2090
Kavangire...	84.606	520	16.8	13.3	0.6	79.2	10.5	6219

One crop of plant and four of stubble, then, gives us an average yield of cane and sugar per hectare for the Kavangire of three times that of the native striped cane, it being interesting to note that the average yield of the native striped cane in Tucumán in the five years under study (1911 to 1915 inclusive) was consid-

* Strange as this may seem, this represents the average yield of the native canes in Tucumán for the ten years previous to the establishment of the Tucumán Sugar Experiment Station—about nine tons per acre!

erably less than that which we obtained in these experiments at the Sugar Experiment Station.

These, however, are the results of but one planting from these canes; let us see how distinct plantations have conducted themselves, thus avoiding the always dangerous tendency to form opinions from one single experiment. Although substation experiments all over the Province had confirmed the above results through the crop of 1913, we resolved that year to start a new series of experiments in the Central Station, selecting for this object a piece of land which had been growing alfalfa for the previous two years, and which, therefore, was in splendid shape for cane. The plot was well prepared early in July, the cane being planted in deep furrows 5½ feet apart, and covered with a small share plow. Germination was quick and good, there being no frost in 1913, and the germinative propensities could, hence, be carefully studied. This is an important and indicative factor in the success of the Kavangire cane, and its significance may well be appreciated from a glance at Table 4. Beginning about the middle of December, counts were made at frequent intervals of the number of sprouts above the ground, these counts being carried on until the Kavangire began to sucker.

TABLE 4.—GERMINATION TESTS.

Variety	Number of Sprouts Above Ground, per Row of 100 Meters								
	Sept. 18	Sept. 25	Oct. 2	Oct. 9	Oct. 16	Oct. 23	Oct. 30	Nov. 6	Crop
Av. native striped and purple	34	85	121	143	169	207	244	278	682
Kavangire	62	208	360	476	537	602	680	791	2366

Nothing could show better than these counts, the inherent vigor of the Kavangire. From the first moment of germination the Kavangire was producing twice as many stalks as the native cane, and by October this proportion has increased to three times as many. At crop time we found that this latter had more than held good.

Now let us see the results given in the crops of 1914 and 1915, which were plant and stubble respectively.

TABLE 5.—RESULTS FROM THE SECOND PLANTING.
I.—AVERAGE OF NATIVE STRIPED AND PURPLE.

Age	Met. Tons Cane per Hectare	Av. Weight Stalks, Grms.	Chemical Analysis					Kgs. Sugar per Hectare
			Brix.	Sucrose	Glucose	Purity	Mfg. Value	
Plant, 1914...	25.26	615	17.3	14.1	0.2	83.2	12.0	2122
Stubble, 1915.	30.78	575	14.0	10.7	0.8	76.4	8.2	1767
Average	28.02	595	15.7	12.6	0.5	80.3	10.1	1981

II.—KAVANGIRE.

Plant	83.40	590	15.9	12.2	0.5	76.7	9.4	5488
Stubble	102.18	550	13.9	9.6	1.5	69.1	6.6	4721
Average	92.79	570	14.9	10.9	1.0	73.2	8.0	5196

Attention should be called to the fact that frost fell very early in the crop of 1915—before hardly any factories had started grinding—and that this fact explains the low purities of that year. Nevertheless, the average results from plant and stubble compare very favorably with those obtained three years previously, as shown in Table 1. The notable point about this table is the splendid agricultural yield and fairly good juice of the Kavangire as plant in 1914, although the juice cannot compare with that of the native canes. In both years the agricultural yield of the Kavangire was three and a half times that of the native canes, and the sugar yield two and a half times as much. As the yield of *sugar per hectare* is the crucial test of any cane, these repeated figures may be taken to represent pretty accurately the comparative value of the canes. Let us see, then, what the average of seven crops of these canes (two each of plant and first-year stubble and one each of second, third and fourth-year stubble) looks like. These averages bear out the individual years' results for plant and first-year stubble, Kavangire yielding over three times more cane and sugar per hectare than the native canes.

TABLE 6.—AVERAGE RESULTS FROM SEVEN CROPS.

Variety	Met. Tons Cane per Hectare	Av. Weight Stalks, Grms.	Chemical Analysis					Kgs. Sugar per Hectare
			Brix.	Sucrose	Glucose	Purity	Mfg. Value	
Native Striped	23.272	640	16.6	14.1	0.4	84.9	12.0	1955
Kavangire...	86.944	530	16.3	12.6	0.7	77.3	9.7	5903

Problems Presented by This Cane.

Professor Townsend goes on to say[1]: "The Kavangire cane is tall-growing and very slender, while the Porto Rican planter prefers a thick cane, because *it appears*[2] to be a better yielder and is handled at less expense; Director May reports a yield at the rate of 70 tons per acre on the Mayagüez plat. The Kavangire cane was imported into Porto Rico from the Argentine a few years ago by Mr. May. In Argentina it has been planted quite largely on a commercial scale, indicating that it is satisfactory from the standpoint of sugar production. It requires a long season for maturity and for this reason has not been recommended for general planting in the Argentine. The sugar per acre is the crucial test, and in this respect it generally stands near the top.

[1] *Loc. cit.*
[2] The italics are the author's.

"After reviewing the available literature in regard to Kavangire, Prof. Earle raises the practical question as to whether or no Kavangire can be successfully used for general planting in Porto Rico. If it can and it retains its immune characteristic, the question of combatting the mottling disease is solved. This question of the practicability of using Kavangire is now under consideration by Prof. Earle and his co-workers in Porto Rico, and at the same time further observations will be made upon the immunity of this variety to the mottling disease. In the meantime its adaptability to the Porto Rican climate and labor conditions will be determined. It appears to be a strong ratooner and to have considerable resistance to root disease, borer, and stem rot. If these indications prove true Kavangire should enable the grower to keep his fields in profitable production longer without replanting than is possible with the varieties now in use. This will reduce the cost of production, even though the habit of growth and quality of the cane should make it a somewhat more expensive variety to handle and to mill."

These are the same difficulties which presented themselves when we began our campaign five years ago to replace the rapidly degenerating, though thick and pretty, native canes with the thin, rapid-growing, but not at all aesthetically appearing Java 36 and 213, which have since been universally adopted in Tucumán, only a few rows of native cane being occasionally seen today, carefully guarded and nursed as an invalid might be by the friends of his youth. In this connection I can do no better than quote the first part of the article already cited in the "International Sugar Journal" for January, 1914, which, in view of the events of the past five years, has turned out to be almost prophetic:

"The first thought that would probably strike one upon seeing specimens of our most promising canes is that those which appear to be giving the best results to date are canes of small diameter. This we must grant at the outset and must also state here that, from the two years' results we have now obtained, *the thin canes as a class seem more promising than most of the larger ones.* We are inclined to admire a thick, heavy cane and it is but natural. Yet, with some very few exceptions,[1] these large canes have not sprouted so readily nor given us so thick a stand as the thinner ones.[2] In view of the fact that so many of our promising canes are of small diameter, it seems advisable to call attention to a few of their good points which are frequently overlooked:

"*Firstly.* As will be seen further on, from the figures given, the fact that a cane is thin does not signify that the average weight of stalk is less than that of the thicker ones. With us, and generally in the Province,[3] thinner canes have

[1] These exceptions have since disappeared.

[2] There is no doubt that, from the aesthetic point of view, we are all inclined to admire a thick, heavy cane, exactly in the same way that it is pleasing to look upon a well-built, fine-looking man. Nevertheless, none of us would employ this splendid-looking physical type in our businesses in preference to a smaller and less attractive man if the latter could do his work better and give us better financial returns as the result of his labors! If it be almost axiomatic that the biggest men do not always make the best soldiers, it is equally true that the most beautiful plants are seldom the most useful to the economy of men. In business—**and agriculure is the most important of all businesses**—utility weighs more in the balance than beauty—the practical result must in the long run count far more than the aesthetic effect. And, after all is said and done, is not that plant most beautiful which helps most towards educating our children, improving our homes, and making our farms healthier and more attractive?

[3] We can now say, "Generally in the Argentine sugar sections of Tucumán, Salta and Jujuy."

attained considerably more height than the thicker ones and, with one or two exceptions, the average weight of stalk of these, calculated from several thousand canes, compares favorably with that of the thicker canes, and very often surpasses the average weight of the canes of the place grown under identical conditions.

"*Secondly.* While we must grant that it would probably cost a little more per ton to strip very thin cane for milling, if we consider the heavy stands of most of them and the short distance a man has to walk to cut a large number, we can see that this objection, too, is not an insurmountable one.

"*Thirdly.* A frequent objection that is made to these canes is the difficulty of milling them, on account of the higher fiber content, as compared with the native purple and striped canes. We do not consider that the higher fiber content is a disadvantage; in fact, *we are inclined to esteem it a decided point in favor of the thinner canes.* In Table 5[1] will be found the results of a series of analyses of the various varieties for the fiber contents, these figures showing that these canes run high—far higher than the canes of the place—in fiber. Every additional kg. of fiber which we have in our cane means that much less wood under our boilers; and that much money saved if we can get extractions from these canes comparable to those from the larger ones.

"Despite opinions to the contrary, which we have frequently heard expressed, we do not doubt that this can be done with a proper adjustment of the rolls, even if this should signify a slightly decreased grinding capacity, or, at least, that should these canes continue to prove a success, so comparable a quantity (of juice) could be obtained that the increased tonnage would more than repay for the slight decrease in percentage of juice which may result. We have made a considerable number of tests with a small electrically-driven 3-roller mill, which gives us about 70 per cent extraction with the native canes,[2] and have found that even with the hardest of these canes, the Kavangire, we could get an extraction, without difficulty, within one or two points of that of the purple and striped canes of the country, and at the same time obtain a bagasse considerably drier than that from the native.[3]

[1] Fiber content of the native cane averages 10.6 per cent and of Kavangire 13.1 per cent.

[2] By passing the bagasse through the mill once also, thus simulating the work of a 6-roller mill without crusher.

[3] We find, from official figures of the Java Experiment Station, that, in 1912, twenty-three factories had an average content of fiber in cane, during all the crop, of above 13 per cent (the fiber content of the Kavangire), while seventeen worked cane with an average fiber content of less than 11 per cent (more or less the fiber content of the Tucumán native canes). Now, condensing the figures for these two groups and making the averages for each one, the results obtained by the factories grinding cane with high and low fiber content may be judged by a glance at the following table:

RESULTS OBTAINED IN JAVA FROM FACTORIES GRINDING CANE OF HIGH AND LOW FIBER CONTENT.

Fiber in Cane, Per Cent	No. Factories	Per Cent Sucrose in Cane	Per Cent Sucrose Extracted on 100 per Cent Cane	Per Cent Juice Extracted on 100 Pts. Juice	Per Cent Fiber in Cane	Bagasse Data		
						Per Cent Sucrose	Per Cent Humidity	Per Cent Sucrose Lost
Below 11	17	12.59	11.49	91.3	10.58	4.72	48.45	1.10
Above 13	23	12.25	11.06	90.3	13.61	4.29	44.99	1.18

There was little difference, then, between the results obtained by the two groups, the most important one, from the calorific standpoint, being that the bagasse from the high-fibered cane had 3½ points less humidity. The average per cent sucrose in cane was slightly better in the group of the **ingenios** grinding low-fibered cane, and they obtained

"*Fifthly.*[4] Most of these thin canes seem very much more free from the attacks of the borer (*Diatroca saccharalis*) and accompanying diseases than the heavier canes. This is probably due both to their small size and to their increased hardness."

In regard to the latter point, the following data are interesting: In 1912, Mr. T. C. Barber, then Sub-station Superintendent of the Tucumán Experiment Station, made counts of the number of average canes of the native and Kavangire varieties in the Experiment Station plats, noting the number of invested joints as compared with the total number of joints in each lot. Table 7 shows the results of these counts.

TABLE 7.—INFESTATION WITH THE BORER.

Varieties	Joints Examined	Per Cent Joints Infested
Native canes ...	1776	41.3
Kavangire	326	15.6

Table 7 shows us that there is a tremendous difference in the infestation between the very thin Kavangire and the heavier native canes growing in close proximity to each other, the latter showing almost three times the number of infested joints that the Kavangire does. In view of the fact that the borer is indirectly responsible for many of the diseases of sugar cane, it may well be appreciated that this is no unimportant point in favor of the Kavangire.

CONCLUSIONS.

Most of the objections to this type of cane are based on conditions, then, that can be controlled—objections which have been accumulated in the Argentine when gradually replacing the native varieties by the new Java canes recommended and pushed by the Tucumán Sugar Experiment Station. The fact that the Kavangire is a late maturer in Tucumán has inhibited its use on a large scale in Argentina, but this factor would probably be of little importance in Porto Rico, where all canes have longer growing seasons than those of the sub-tropical Argentine sugar districts, with their long droughts and heavy frosts.

One point has not been mentioned by the Porto Rico investigators which is of capital importance—the quick inversion of the juce of the Kavangire once the cane is cut. This is a very pronounced phenomenon, with both the Java and Kavangire varieties, but is by no means an insuperable difficulty—in fact, it has proved rather a blessing to the Argentine, having imposed better organization in the field and more prompt deliveries of cane to the mill, whereas, even though the native canes invert much less rapidly, much sugar was undoubtedly lost in the old days by carelessly leaving the cut cane four or five days in the field.

The stripping of this cane represents a real difficulty, as the leaf-sheath adheres very tenaciously to the stalk, and the adoption of Kavangire would inevitably bring an increase in the cost of harvesting, as the adoption of the Java canes

[4] "Fourthly" deals with increased frost resistance, a point of no importance in Porto Rico.

in Tucumán has done, but this extra cost of crop is much more than recompensed by the reduced cost of cultivating this prolific and quickly-closing variety. If the Kavangire turns out to be the only variety in Porto Rico immune to the mottling disease, it will be adopted as the staple cane of the Island, and the economic conditions relative to its adoption will be worked out by its progressive scientists, growers and manufacturers just as they have had to be in Tucumán.

The young Tucumán Sugar Experiment Station has saved the Tucumán sugar industry from extinction—perhaps the bread it has cast upon the waters may be washed up manifold upon Porto Rico's verdant shores.

[H. P. A.]

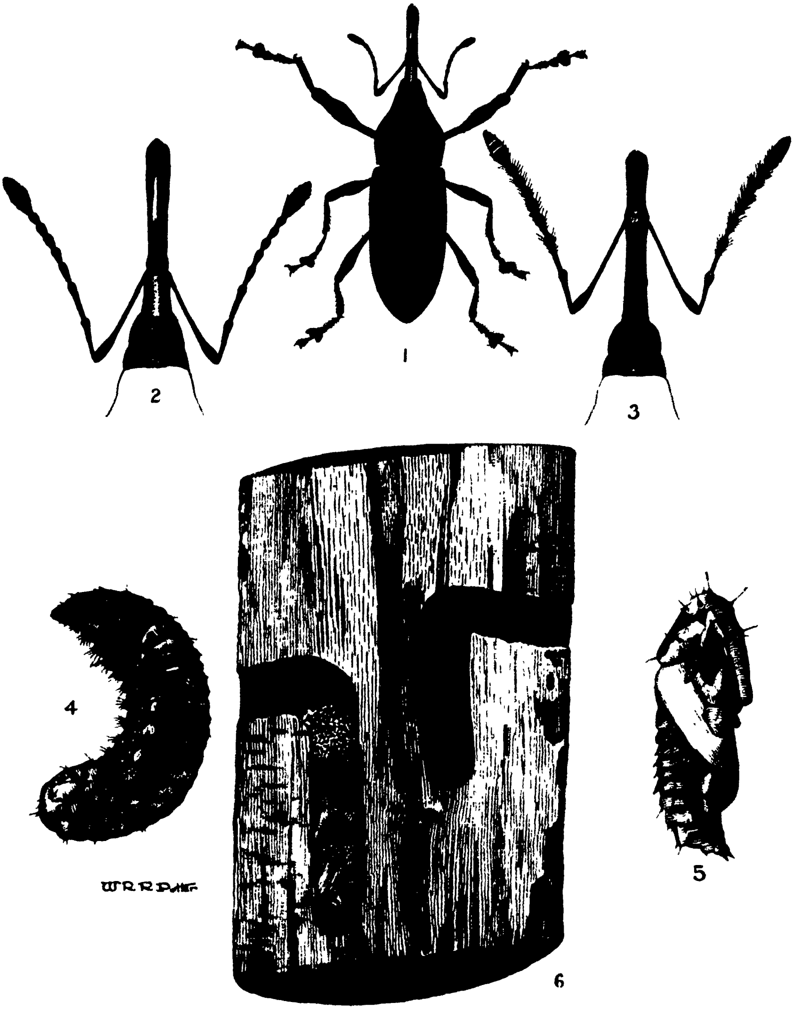
The Olapa Weevil, Nesotocus Giffardi.

By O. H. Swezey.

This large strange beetle (Fig. 1) is one of the endemic Hawaiian insects which attacks trees very abundantly when in the right condition to be attractive to them, this condition being a state of decline, or diseased condition, or when the tree has been subject to injury. The trees attacked by these weevils are the species of *Cheirodendron* (Olapa), native Hawaiian trees which in places make up a conspicuous part of the forest cover on the watersheds.

The beetle itself is generally considered a rare insect, not being collected ordinarily more than an occasional specimen at a time. At one time, however, in company with other entomologists, I found a tree that had fallen over in a landslide along the Castle Trail on the Kaumuahona ridge, Oahu, which had hundreds of the larvae feeding in the inner bark and outer part of the wood beneath the bark. Many of the larvae were full-grown and had eaten into the wood and constructed a cell in which to pupate (Fig. 6). A few weeks later the same tree was visited and many specimens of the beetle were obtained by cutting into these pupal cells and finding the matured beetles which had not yet issued from the cell. Apparently the tree had been attacked soon after it had fallen and the bark was beginning to ferment or decompose, becoming attractive to the female beetles which oviposited in the bark. The larvae fed on the bark while in this condition, becoming full-grown (Fig. 4) before the bark had entirely dried up, then had eaten into the wood of the trunk and branches for the formation of the pupa (Fig. 5), as before mentioned. The whole tree was thus attacked, even some of the large exposed roots.

At the same time, at other places along the trail where these trees were to be found, the work of the larvae of this weevil could be found in dead or dying branches. Sometimes the larvae were found feeding in apparently healthy living tissues of the branches not far from where these were in a dying condition. In these cases, however, the larvae were not at all numerous, as was found in the fallen tree, and the indications were that healthy trees were not injured by the weevils, only being attacked where there were dying branches. It is an illustration of the behavior of many other native wood-borers which normally are rather rare



Olapa Weevil (**Nesotocus Giffardi**).

Fig. 1. Adult beetle.
Fig. 2. Head and antennae of female.
Fig. 3. Head and antennae of male.
Fig. 4. Larva.
Fig. 5. Pupa.
Fig. 6. Section through branch of **Cheirodendron** tree, showing pupal cells and one pupa in situ.

and not particularly injurious to the trees, but where a tree has been considerably injured, or in a diseased condition, or blown over by the wind, or fallen from other causes, then it becomes greatly attacked by the particular native borer which is attached to it. The most of the important native tree borers are particular which trees they associate with and are usually to be found only in connection with these trees, as, for example, ten species of *Clytarlus* and six species of *Plagithmysus* beetles, which attack the koa tree, but no other kind of tree. Similarly, three species of *Plagithmysus* are attached to the lehua tree. Other species of this same genus of beetles are attached to their respective trees.

On each of the other islands, Kauai, Maui, and Hawaii, there is a different species of *Nesotocus*, all closely similar, which similarly attack *Cheirodendron* trees on their respective islands. On one occasion, while collecting insects in the forests along the Upper Hamakua Ditch in the Kohala Mountains of Hawaii, I came across two *Cheirodendron* trees in a dying condition, from which I was able to collect quite a number of adult weevils (*Nesotocus munroi*), and which had numerous larvae feeding in and beneath the bark of the partially dead branches, the same as I had found them in the instance mentioned on Oahu. In the adjacent region were numerous young trees of *Cheirodendron* 10-15 feet high and in healthy condition. I had searched diligently on these trees for evidence of the presence of *Nesotocus* weevils, and had been able to find but an occasional specimen where they were working on dead branches here and there.

Mr. W. M. Giffard has similarly reported that in July of 1920 he had found the adults of *Nesotocus munroi* abundant on injured trees of *Cheirodendron* where burning and clearing of the forest was being made for a garden at Kilauea, Hawaii. Many *Cheirodendron* trees occur in the region, but by persistent search at many times only rarely was a specimen of the weevil found. However, they appeared in large numbers, being attracted to the injured trees in the clearing when these were in just the right condition for them.

Figure 7 shows views of portions of the trunk of a tree that the writer observed along the Manoa Cliffs Trail on Mt. Tantalus. This was a standing trunk of a large *Cheirodendron* tree, from which the bark had fallen, exposing thousands of the openings of the pupal cells of this weevil. Evidence was not at hand to determine whether the weevil larvae had been the cause of the death of the tree, or whether their work was performed after the tree was dying from other causes. From the fact that most of the large trees of other species in the immediate vicinity were also dead would indicate that some general cause was responsible for the death of the trees, and that the weevils, as in the other instances mentioned, had attacked the *Cheirodendron* tree after it had reached the dying condition.

Many dead tree trunks in the Hawaiian forests are found filled with holes which are the work of the larvae of wood-boring beetles. It is considered by some that this is sure evidence that the borers have killed the trees. The entomologists who have made studies of the habits of these beetles are agreed, however, that these beetles do not attack and destroy the healthy trees. It is only the trees which have become injured, diseased, or in a dying condition from other causes that are so severely attacked by the beetles, and brings about the appearance which to the casual observer indicates that the borers have been responsible for the death of the tree. The truth of the matter is that in the natural forests, in their normal healthy condition, these borers are scarce and very difficult to find, only keeping up their existence on the dying branches that are always to be found in healthy trees, being choked out below by the shading of the upper growth of the trees, or in an occasional injured or fallen tree. If one happens to come along at the right time he may find an abundance of beetles which have been attracted to this injured or fallen tree. It is only by such good fortune that good series of many of the species may be obtained.

A point to be emphasized is that when dead trees full of borer holes are observed in the forest-cover on our mountains it is not to be interpreted that the

Fig. 7. Photos of portions of the trunk of a dead **Cheirodendron** tree. The numerous round holes are the openings of pupal cells, from which beetles have issued when mature.

borers are killing off these forests. The primary cause of the death of the trees is some other detrimental conditions, and the borers have been a secondary feature, which often, however, may hasten the ultimate death of the trees.

A Convenient Mosquito Poison.

Camphor and para-dichlorobenzene have been successfully used to keep down mosquitoes around dwellings, in fern-houses, and places where the use of oil is not possible. Two grams of powdered para-dichlorobenzene, or two grams of camphor (lump or powdered) to each liter of water, renewed every ten days. This is effective against yellow-fever mosquitoes, and is convenient to use in many places where they breed, such as flower vases, pot-pans in fern-houses, water containers, ant guards round refrigerators, etc.

[F. M.]

Preparing Boilers for Inspection.*

Methods to Employ for Rapid Cooling; Removing Vapor from Drums; Precautions with Leaky Stop Valves.

By Edward Rutledge.

Boiler inspection, never a pleasant task, is often made more difficult by well-intended but misdirected efforts of the attendants. The preparation of the boiler is usually left to the men in the fire-room without any supervision or directions of the manner in which they shall proceed. If the boilers are to be off the line for only a short time, the men will, in an attempt to cool them as much as possible, throw open all the doors in the setting as soon as the fires are drawn.

This is the condition that the inspector often finds when he enters a boiler room—it is the rule rather than the exception. The men do not seem to realize that with the doors wide open the air circulation is almost negligible, and there is only a slow loss of heat by radiation. They are not inclined to reason out little problems of this nature for themselves, but hardly more than a suggestion is necessary to show them that a strong current of air will carry away more heat in a few hours than would radiate off in a night.

More than once the writer has found a boiler seemingly unbearably hot. The attendant is much concerned over his lack of success; the fire was burnt out early the previous afternoon and the doors in the setting opened. The night watchman had opened the blowoff shortly after midnight; early this morning the plates had been knocked in and a stream of cold water had been going into the boiler since that time. He honestly thinks he has done everything possible to cool that boiler. He has, as a matter of fact, done about everything he should not do; but to save time, and for other reasons, we do not tell him—we show him.

First, that stream of cold water is shut off. Of all contemptible treatments, the water cure deserves first mention. In a hot boiler, not only is it apt

*Power Plant Engineering, September 1, 1920.

to set up severe contraction strains, but the vapor caused by its striking the warm plates makes a moist, sticky, enervating atmosphere that very quickly saps the good nature out of anybody who works in it.

In passing, it may be said that next to water in a warm boiler, water sprayed into a cold boiler is the next least desirable. It leaves the surface wet and dark, making it difficult to discern what would be readily apparent in a dry boiler. It may even completely hide some condition at a place that can only be examined at long range.

So much for cussing the water cure; if it takes root, the effort will be one well spent. Now, take the fireman by the arm, as it were, and gently intimate that the doors in the setting, excepting the fire doors, should be closed and the main damper and flue damper opened wide.

In 30 minutes, unless conditions are unusually bad, the boiler can be entered and examined. It is not intended to give the impression that the boiler will be cool; a shell in a heavy setting of brick cannot be brought down to the temperature of the boiler room in 24 hours or less. If, however, the draft is utilized as outlined, the boiler will be in very fair condition for inspection.

While the cleaning of the combustion chamber and gas passages is in progress, the draft will of course be checked. As soon as the cleaning is completed, the doors should be closed again and the dampers set so that the flow of air will continue.

Leaky stop valves are often a source of difficulty in cooling a boiler. Double stop valves offer a means of overcoming this, but even these are a disappointment unless both valves are closed and the drain valves between them opened. That little drain valve is so often overlooked; its only function is that which its name implies—to drain between the two stop valves. It is the attachment that makes the double stop valve arrangement worthwhile.

With only one stop valve between the boiler and the main, severe leakage by the valve is a source of real danger to one entering the boiler. It is a condition that often is not known to exist until the boiler is opened. The time is then too short to put the valve in proper condition and other means must be devised to overcome the difficulty. The simplest way, of course, is to shut off all steam from the main if conditions will permit. Usually steam must be kept on the main and it then may be necessary to blank between the boiler and leaky stop valve; or to remove a safety valve. In a drum boiler with two or more drums, a very effective expedient is to place an electric fan close to the manhole of one drum. The slight pressure caused by the air current will be sufficient to check the leakage into the drum, and as long as the fan is in operation, the vapor will be forced into the other drum. The fan need not be started until a few moments before the drums are to be entered.

The essential points brought out have been to get the water out of the boiler to be inspected as soon as possible, to refrain from washing out until after inspection, to keep out vapor from leaky stop valves and to maintain an air current through the boiler every moment possible from the time the fire is drawn.

To this may be added the removal of manhole plates, handhole plates and tube caps. These should be knocked in as soon as the water is out. The manhole plates should not be allowed to drop into the boiler, to break off a feed pipe

or surface blowpipe as is often the case. Back the nut off the bolt in the manhole plate until only about half of the nut remains on the stem. Standing so that the cloud of vapor that will issue may be avoided, strike the plate a few sharp blows with a heavy hammer until the gasket joint is broken. Do not attempt to remove the plate at once, but leave it suspended in the hole until it has cooled sufficiently to handle.

Handhole plates and tube caps should be handled in the same manner. The interior of the boiler is thus vented from the earliest possible moment. With the air drawing through and the other essential points observed, the boiler will be in the best condition attainable, not only for the inspector, but for the men who are to remove the soot and ashes.

Standardizing boiler construction has, within the past few years, brought about better design, better material and better workmanship. Rules and codes cannot, however, safeguard boilers against the wear and tear of service other than to provide for the periodic inspection of the vessel.

Important, then, as is the work of the inspector, so, too, is the proper preparation for inspection. A man may struggle and squirm and wriggle through a hot boiler; he will do his best, but he is only human and his best under such harrowing conditions cannot equal his best when conditions are more favorable. Nor is he gifted with second sight to see through a cloud of dust or a heavy coating of soot.

Give, then, a little more consideration to the preparation for the boiler inspector. A few detail instructions to the man is often the only extra effort required, instructions which, if followed, will in many cases give better results and even lighten the labor involved. [W. E. S.]

The Efficient Burning of Oil Fuel.*

A Summary of Good Practice.

By Allen F. Brewer.

The question of the efficient burning of oil fuel is perhaps one of the most vital before the power plant engineer today, who is using such fuel or contemplating converting his plant from coal to oil burning. A saving in fuel cost, no

* Industrial Management, July, 1920.

This article is a compilation of methods and practice gathered from numerous sources and tests prepared to aid the operating engineer in attaining the best results in the burning of oil fuel. The principles discussed are those that concern the supply of air for combustion, firing temperature of the oil, firing pressure of the oil, appearance of the flame, types of burners, care of the burners, design and construction of the furnace, rate of combustion and the details of construction of the burners, furnaces and furnace linings. A few paragraphs are devoted to rules for preventing damage and accidents in burning of oil. This article is especially timely because of the increased use of oil in power plants and the continuous changing over of coal-burning furnaces to the utilization of oil.

Mr. Allen F. Brewer was graduated from the Massachusetts Institute of Technology in 1914. Up to the outbreak of the war he was assistant engineer and inspector in the Appraisal Department of the Public Utility Commission of the State of New Jersey. He enlisted in the Navy, receiving the rank of ensign. For the past year he has been an engineer with The Texas Company, specializing in the application of oil fuels. He is an associate member of the A. S. M. E.—The Editors.

matter how slight, will contribute toward added plant efficiency, and the aggregate saving over an appreciable length of time will be a convincing argument in favor of more intelligent handling and burning of oil fuel and the training of firemen with this purpose in view. In reality, the burning of oil as a fuel under boilers is a science. This fact has been seriously appreciated by the United States Navy in carrying out exhaustive tests and in the training of firemen in the efficient burning of oil. It is not the purpose in this article to set forth personal opinion in any manner, but rather to offer a compilation of methods, gathered from numerous sources and tests, and personal experience, which will aid the operating engineer to attain the best results from his fuel and plant.

Under existing conditions of consumption and production, the question of conservation must be given most serious thought. Probably the most common question which will be raised by a prospective consumer of oil fuel is: "Can my supply be assured over the period of my contract?" or, in other words, would there be possibility or probability of temporary stoppages of the oil fuel bulk supply to the consuming market, which would vitally affect power production for our daily needs. It may be safely said that present opinion as to the probable petroleum resources of the world is far from agreement. To assume any definite limitations as to such resources is difficult. The enormous advance in the past five years in the usage of oil fuel as a substitute for coal renders an estimate of its probable future usage, supply and cost, almost an impossibility. At all events, it is safe to say that we are faced with the condition of increasing consumption with decreasing production, according to present indications from the known producing oil fields of the world.

False Ideas of Oil Burning.

There are too many operating engineers who still labor under the false idea that to burn oil fuel all that is necessary is to turn the oil valve and supply sufficient air to prevent heavy smoke. True, the oil will burn and steam will be generated, and perhaps a higher efficiency will result than when burning coal. Therefore the engineer feels confident his plant is developing excellent economy. Yet, it is surprising how the efficiency can be increased by a little study of the principles of combustion, the appearance of the flame, the proper pressure and temperature at which to fire the oil, and the requisite amount of air to give best combustion. In brief, the secret of proper firing of oil fuel is to attain complete combustion. Incomplete combustion will result in a direct waste of fuel which is irrecoverable. The primary cause for the latter is the use of too little air, which will result in the burning of the fuel to a high percentage of unburned carbon monoxide. The extremes to which poor firing of oil fuel can go far exceed those of coal. Negligence of the principles of combustion or lack of care in the firing of coal will result in the fire ultimately going out. With oil, the fire will probably never go out, but wastage of oil will occur to an unthought of extent, though the fire itself will not indicate such to the unpracticed eye.

The principles involved in arriving at so-called perfect or complete combustion are best taken up as individual studies, and the essential features are re-

viewed in the following paragraphs in their general order of importance to the operating engineer. In effect they may be summarized under the following headings:

Air required for combustion;
Temperature of firing of the oil;
Pressure at which the oil is fired;
Appearance of the flame;
Burners and their care;
Design and construction of the furnace;
Rate of combustion;
Straining of oil fuel;
Furnace lining;
Rules for prevention of casualties;
Flue gas analysis;
Standardization of equipment.

Air Required for Combustion.

The actual amount of air required by a boiler to insure complete combustion of the fuel fired will depend entirely on the furnace design and construction, the means of admitting air, the type of burners used and the degree of atomization obtained therefrom.

In order that oil fuel may be completely and efficiently burned, it not only must be delivered under a constant, uniform pressure in a finely-atomized state, but the resultant spray must be mixed with air in proper proportions to the amount of oil being delivered. The use of only the theoretical amount of air required for combustion is usually insufficient, due to imperfect mixing of the gases, restricted combustion chamber volume and too short a time available for complete combustion. In general it may be said that approximately fourteen pounds of air are required for complete combustion of one pound of oil fuel of average gravity. The volume of a pound of air at 62 degrees Fahrenheit is 13.14 cubic feet; therefore, approximately 184 cubic feet are required per pound of oil for perfect combustion. To this would usually be added 10 to 20 per cent to allow for the contingencies quoted above. On the other hand, too high an excess of air will mean that heat must be absorbed to raise this excess approximately to the temperature of combustion, and subsequent loss will result when this air passes up the stack in an overheated condition; with the result that another extreme will be met and the boiler evaporative efficiency will be lowered.

Appearance of Smoke.

The appearance of smoke at the stack is probably the most reliable guide other than the flue gas analysis as to whether the requisite amount of air is being supplied. Too little air will result in incomplete combustion and heavy, black or greyish smoke. Too much air will be indicated by more or less dense, white smoke. Under practically perfect combustion conditions the smoke should have the appearance of a greyish haze as it leaves the stack. The presence of blackish streaks in this haze is a probable indication of dirty burners. No smoke may

indicate the proper amount of air or an excess above that required. In practice it is well to regulate the air supply either by the damper or blower until a heavy greyish smoke appears, and then open the damper or speed up the blower gradually until the smoke takes on the desired greyish haze appearance. Too little air, or air delivered at too low a velocity to a mechanical burner, is a direct cause of so-called vibration or panting of an oil flame in a boiler. The remedy is to increase the air supply and velocity, or decrease the oil being fired by temporarily cutting out the burner from which vibration is occurring. Vibration, if allowed to continue, will have a detrimental effect particuarly on the furnace lining, and ultimately loosen the brick work.

In general, suitable means should be installed in order that regulation of air supply may be maintained to meet any demand upon the boiler and oil supply. Where a steam or air type of burner is involved, receiving its air for combustion via the ashpit door and a checkerwork of firebrick in the furnace floor, such checkerwork should be constructed to allow passage of the maximum excess of air required for peak loads. The required area of air openings in the checkerwork will be a considerable variable, dependent chiefly upon the boiler capacity and the draft to be maintained. Assuming a draft of one to two-tenths of an inch of water, a total checkerwork area of from 2½ to 3 square inches per horsepower will be adequate to operate a boiler from rated capacity to 50% overload. The control of actual air supplied can be carried out by manipulation of the ashpit doors or the damper at the uptake, leaving either one wide open and adjusting the other to give the requisite air supply. Experience in a variety of cases has developed a general rule that it is best practice to regulate air by means of the damper leaving the ashpit doors wide open.

Essential Features of Draft.

The essential feature of successful draft operation is to confine the actual draft to the uptake and stack, carrying very little within the combustion chamber proper. It is evident that any amount of draft in the combustion chamber will tend to hasten the passage of the gases excessively, change their natural direction of travel so that they will not reach to all corners of the combustion chamber, and cause leakage of air through the boiler setting or brickwork. The practice of controlling draft by the damper will maintain the best draft principles, i. e., little or no draft in the combustion chamber, natural travel of the gases to all parts of the combustion chamber and heating surfaces, and least setting leakage of air. There will be times, however, when the ashpit door will require manipulation as well as the damper to gain suitable draft, particularly where light loads are prevalent.

Where a mechanical type of burner is in use, the air supply is in general received through a series of vanes surrounding the burner, and regulation is best carried out by varying the speed of the blower as demands may require. The velocity of air supply in this case may be said to have greater bearing on perfect combustion than the total volume, inasmuch as the ultimate volume of excess air may be thereby decreased, due to greater velocity being imparted to the atomized oil, since each particle of the latter will be more completely surrounded

by the requisite theoretical amount of air for perfect combustion to the highest percentage of CO_2.

Temperature of Firing of the Oil.

To properly and completely atomize oil fuel at moderate pressures and enable it to be more readily burned, it must be heated sufficiently to reduce its viscosity. The extent of heating will, of course, depend entirely on the grade of oil and its original viscosity. In general a temperature in the neighborhood of 125 degrees Fahrenheit for steam or air-type burners, and 150 degrees Fahrenheit for mechanical burners will be found suitable to heat the oil to, in order to reduce it to a viscosity ranging between 8 and 15 degrees Engler (300 to 560 seconds Saybolt), such a viscosity having been determined by experience to give the best atomization results. Overheating the oil to any extensive degree will produce a steadily decreasing burner capacity relative to the temperature. On the other hand, heating to the proper degree will increase the burner capacity and its ability to atomize the oil completely, and in the case of a steam or air-type burner less steam or air will be required for atomization. Therefore, the engineer should guard against overheating even more carefully than against underheating, and gage his ultimate temperature to correspond to actual burner capacity tests on his particular oil.

It is generally considered poor practice to heat oil fuel above its flash point at any time in any part of the system other than the burner, inasmuch as this will cause carbonization at the burner tip, precipitation of carbon in the heating and distribution system, and will involve danger of explosion should leaks be present in the system. The question of the potential danger involved when oil fuels are heated above the flashpoint has aroused considerable interest among combustion engineers of late. To bring certain of the so-called heavy Mexican crude oils to a suitable pumping viscosity of, let us say, 15 degrees Engler, it will be necessary to heat to the neighborhood of 200 degrees Fahrenheit, or considerably above their flashpoints. Such oils, however, have such a low content of volatile hydro-carbons, tending to flash at lower temperatures, that even at 200 degrees Fahrenheit a flash test will not be indicative of ever-present danger since the flash will only occur as the more volatile constituents are freed from the body of the oil, there being no possibility of the entire body of the oil flashing simultaneously. In general, such heavy crude oils at the wells will flash at ordinary room temperatures of 70 to 90 degrees Fahrenheit. Their volatile hydro-carbon content is usually below 5 per cent, however, and on weathering or pumping into tanks or tank ships such constituents as gasoline and benzine will vaporize continually. As a result the flash will rise to even as high as 160 degrees Fahrenheit by the time such an oil is delivered to the tanks of the consumer.

In actual practice heating of oil fuel preparatory to firing is carried out by means of oil heaters, using exhaust steam preferably as the heating medium. It is not purposed to describe any of the general types of heaters herein, this subject being foreign to the discussion. It is fitting, however, to touch upon certain of the principles of operation. The question of oil leaks to the steam side of heaters is of importance due to the fact that oil would thus be carried over to the condenser and to the boilers, ultimately causing overheating of the boiler parts where-

oil deposits have collected, corrosion, priming, and a decrease in steam production. It is good practice to install traps adjacent to oil heaters suitably fitted so that the water may be drawn off and inspected for oil. In the event of oil being discovered, the heater should be immediately cut out and repaired.

Pressure at Which the Oil Is Fired.

In order to insure proper combustion of oil fuel the latter should be fired at a steady, uniform pressure. Variations in pressure and supply may be the cause of vibration or panting in the furnace, occasioned by unsteady flow of the oil from the burner tip. Pump pulsations arising from inequalities in the piston strokes are the most common causes of pressure variations where reciprocating types of pumps are in use. This pulsation may be reduced or corrected as nearly as possible by the installation of air chambers on the oil discharge side of such pumps, the chambers being maintained fully charged and non-leakable at the pumping pressure.

In many respects the oil pressure will govern the rate and completeness of the burning of oil, other factors being in conformation with good practice. In general it may be said that up to about 250 pounds pressure atomization will be increased as the pressure is increased. The proper pressure to use will, of course, depend on the grade of oil; the chief objective being ultimately to atomize thoroughly the oil in the burner. It is considered good marine and industrial practice to maintain a uniform pressure, sufficient to insure thorough atomization under normal burning conditions. If increased load is applied it is best to cut in another burner, if this is possible, or as an alternative increase the pressure to feed more oil to the burners in use; vice versa, if the load is decreased it is best to cut out a burner, if possible, rather than reduce the pressure from the normal. The normal pressure in every case should be sufficiently high to prevent vibration so far as possible and to insure good atomization.

A good burner will atomize properly an average viscosity oil fuel at as low a pressure as 30 pounds. It is not intended to recommend any definite pressure to be adopted, due to the great variety of burners and oils on the market today. It is safe to say, however, that a range between 30 and 50 pounds for steam jet burners, and 100 to 150 pounds for mechanical pressure burners will give efficient results on crude or heavy topped oil fuels used in any of the well-known burner systems at a temperature between 125 and 150 degrees Fahrenheit. The above ranges of pressures will not involve undue wear and tear on the pumps, and combustion will be well confined to the center of the furnace without possibility of damage to boiler tubes or casing through excessive heating.

It should be borne in mind that the velocity of the oil should be relatively less than that of the air to insure best results, there being less chance that the oil will strike the back wall of the combustion chamber before combustion has taken place.

It is fitting also to mention the rotary types of pumps, which are based on the rotating plunger principle, as to their value for oil pumping. In general they have been found more applicable to mechanical pressure jet systems than where steam or air was used as the atomizing medium. Such pumps have the

advantage in that they give a very uniform oil pressure, and do away with the air chamber.

Appearance of the Flame.

The furnace should be frequently inspected through the peep holes to ascertain the condition of the flame or flames, and thereby judge the extent to which combustion is being carried out. The flame, its color and appearance is one of the best indications to the engineer, of the efficiency attained in burning oil fuel. Under ideal conditions the gases of combustion should appear bright and clear, with the back wall of the furnace clearly visible. The flame at the burner tip should appear bluish white for about six to eight inches, changing therefrom to a violet and shading to a bright clear cherry red and finally to a soft orange color as it extends into the furnace. Streaks in the flame will indicate a dirty burner tip. Excess of air is indicated by blowing out the flame, and a dense, whitish yellow color thereof. Too little air is shown by a smoky flame and the gases of combustion taking on a dull, reddish yellow appearance, the back wall of the furnace will be less visible or obscured entirely, and the violet hue will disappear from the flame near the burner tip.

Types of Burners.

The chief function of the oil burner is to properly atomize the oil, i. e., to break it up into minute particles, in order that it may present the maximum surface to mix with the air required for combustion. Thorough atomization is, in truth, the greatest secret of complete combustion. The process of atomization is carried out either within or at the tip of the burner by one of the three following mediums, i. e., steam jets, compressed air jets, or mechanical pressure jets.

Steam and air-jet burners are classified as inside or outside mixing according as the oil strikes the atomizing jet within the burner proper or at the nozzle. With mechanical-pressure jet burners the oil is forced through under pressure, the design of the burner being calculated to pulverize the oil and cause it to spray from the tip in a cone of minute, gaseous particles meeting the air for combustion, which in general enters the furnace in heated condition around the burner. In stationary boiler and locomotive practice the steam-jet burner is in most common use. The flame therefrom may be either flat or conical, the flat type being the most usual.

Steam-jet burners will require under average conditions from three to five per cent of the total steam production for atomization. Such steam should be as dry as practicable for best and most efficient results. Moisture will increase fuel consumption due to the necessity for evaporating the water in the steam and subsequently raising it to the temperature of the furnace. The chief advantages of the steam-jet burner are: the more regular spread in the intensity of the flame throughout the furnace, and the simplicity of equipment required. The air-jet burner, while used extensively in stationary boiler practice, is generally most common in metallurgical and industrial furnace work where an intense flame is desired. The flame as in the steam-jet burner may be either flat or conical, dependent on the type of burner.

The mechanical-pressure burner, while most popular for marine boiler installations, is, however, frequently met with in stationary practice. It has the great advantage in that none of the steam produced is directly used for atomization, and it can be more readily adjusted under wide load variations. The flame from such burners is of conical shape in practically every case. The rotary type of burner is an offshoot of the mechanical-pressure burner in its general principles. Rotary burners are coming more and more into use for household and building heating and power installations.

Whatever the type of burner, there are certain principles of operation which are common to all. In spite of burner construction, the resultant success of an installation will depend to a great extent on the facility to operate, the ease of operation and extent to which average labor can intelligently carry on the work of the fire-room without unnecessary supervision and training. Ideal burner construction should permit, at all times, of easy installation, rapid inspection, facility to remove quickly foreign matter which may tend to clog it and cheap replacement of parts. It may also be said that the ideal burner should show no difference in operation and its ability to atomize whatever the grade of oil being fired. It should handle the heaviest crude oil, properly pre-heated at the requisite pressure, as easily and cleanly as it would fire a high-grade refined fuel oil. The location of a burner in the furnace is of vital importance in its relation to the localization of heat on the heating surfaces. At no time, whatever the operating conditions, should the flame impinge directly on any part of the heating surfaces. The results of such will be the burning out of such surfaces, premature cooling of the gases and a consequent decrease in efficiency.

Horsepower Capacity of Burners.

The question of forcing burners is particularly pertinent frequently to the operating engineer who may have to meet peak loads with insufficient equipment. Forcing the burners can be done, but it is generally looked upon as bad practice, particularly with steam or air-jet burners, due to the excessive amounts of steam or air required for atomization. Other detrimental features are incomplete combustion, poor distribution of heat, burning of tubes and high stack temperatures. It is therefore most economical in the end to calculate for burner capacity, if possible, to meet peak loads without the necessity for frequent or continuous forcing.

The horsepower capacity of burners is a subject of wide variation, due to the many types of burners on the market and the furnace designs they may be installed with. Rough average figures are, however, quoted as a general guide to the engineer in judging the approximate suitability of his installation to meet existing conditions. A good steam-jet burner, properly installed in a well-designed furnace, should show a capacity in the neighborhood of 400 horsepower. Air-jet burner capacity is so variable that no figures are quoted. Horsepower capacity of mechanical-pressure jet burners is lower than for steam-jet burners. Fair figures would range in the neighborhood of 200 horsepower each. In every case, however, burner horsepower capacity will be entirely governed by the number of burners in use, their type, the furnace design, and total furnace volume.

Care of Burners.

The care of burners is an important factor if they are to be expected to operate to give the results required. When not in use they should be lightly coated throughout with lubricating oil to prevent rust, and stored where free from dust, damage and unnecessary handling. Prior to using, and periodically, after being installed, all burners should be disassembled as completely as possible and well cleaned with kerosene. Care should be taken to remove particles of carbon, especially from the tip, inasmuch as these will cause a dirty, streaky flame with corresponding loss in efficiency. It has been the author's practice to clean mechanical-pressure jet burners daily in marine operation. The frequency for cleaning steam or air-jet burners will depend largely upon the type of burner and its simplicity. This should best be determined from experience and the appearance of the flame. Where burners become clogged with foreign matter they should be immediately cut out, removed and blown through with steam. The most prevalent cause of clogging of burner is carbonization of oil within the burners due to overheating, or the entry of sediment due to faulty straining. Burners should never be cleaned or wiped with waste or cloth liable to shed lint, inasmuch as shreds are oftentimes the original cause of ultimate clogging, especially if the tip or orifice of the burner be rough in any place. It is well to test burners periodically, say monthly or more frequently, for leaks at joints, etc., by use of water pressure at the same pressure as the oil being fired. Such a test apparatus will depend on the facilities at the plant. Usually a length of high-pressure hose coupled to a feed pump and the burner to be tested will give the adequate water pressure. Leakage at burner joints or valves should be promptly corrected, inasmuch as the fire hazard will be materially increased if they are allowed to continue.

The amount of oil fuel burned per burner per hour is a variable dependent on air supply, draft, type of burner and the grade of oil. It is interesting to note certain figures, as a general guide to the engineer. Navy destroyer practice under forced draft has shown in the neighborhood of 500 pounds of oil per burner-hour. Marine practice may be quoted at between 300 and 400 pounds. Stationary practice under normal conditions will range between 200 and 350 pounds per burner-hour.

Design and Construction of the Furnace.

Furnace design plays a most important part in the efficient burning of oil fuel. In fact, no matter how suitable the burner and the methods of firing the oil, proper results cannot be obtained in a furnace not suitably designed and constructed for the use of such fuel. In all cases furnace volume should increase in the direction in which the oil is being fired to insure suitable mixing of oil with the air for combustion, adequate expansion and the complete combustion of the resultant gases prior to their coming in contact with the tubes. The ideal furnace or combustion chamber should be so designed that burning particles of fuel will be entirely consumed therein, before they are carried to and in contact with the relatively cooler parts of the boiler heating surface. For the water-tube type of boiler a flat flame is generally preferred; for the

Scotch (or fire-tube) boiler the conical flame will give the best results. Furnace design should be so calculated relative to the number of burners to be used, that the flames from adjacent burners do not interfere.

Furnace volume plays an important part in furnace design. The actual volume to be occupied by the burning gases has been termed by Mr. E. H. Peabody in his paper "Oil Fuel" as the "effective furnace volume." He further states that "In the burning of oil 'furnace volume' has the same significance that 'grate surface' possesses in coal-burning installations." In the water-tube boiler a unit furnace volume of 60 to 80 cubic feet per burner has been found to give good results. Yet the calculation of this factor will vary greatly, dependent on the type and size of burners to be used, the draft to be carried, and the probable demands on the plant. In all cases, however, the total volume of furnace and combustion chamber, whatever the type of boiler, should be calculated as the "effective furnace volume." For the Scotch (fire-tube) boiler, furnace volume is not such an important factor. Such boilers generally carry one burner per furnace; there is no danger, therefore, of flame interference, and the volume is generally adequate for the average burner.

Rate of Combustion.

The above term, in itself, is perhaps misleading, as to its real purport in the efficient burning of oil fuel. In effect it may be stated as the rate at which the oil should be supplied to the burner, under proper pressure and temperature, in order to insure complete combustion within the furnace before the gases come into contact with the heating surfaces. Failure to arrive at this will probably result in the flame being extinguished from time to time with a tendency for re-ignition in the flues, uptake or stack. To avoid such a condition the combustion chamber volume should be ample to afford complete combustion and a suitable length of gas travel under peak load conditions.

The rate of combustion will be governed primarily by the oil pressure, oil temperature, the volume and velocity of the air supplied for combustion, and the number of burners being used. As has been stated above under "Pressure of Oil to Be Fired," it is considered best practice to vary the rate of combustion by increasing or decreasing the number of burners, and maintaining the oil pressure and temperature constant whenever possible. When this is done the air supply must be varied accordingly, as judged by the condition of the smoke at the stack, the flue gas analysis or CO_2 recorder, if such apparatus is installed, and the appearance of the flame. Governing the rate of combustion by means of the burners will result in a more uniform distribution of the flame. Wherever possible, if varying sizes of burner tips are kept in stock, the rate of combustion can effectively be varied by changing the tips, using a larger tip for increased demand for steam, or *vice versa*. In every case where a number of boilers are in use the number of burners being used per boiler should be the same in order that approximately the same evaporation may be realized from each boiler.

Straining of Oil Fuel Prior to Firing.

Due to the prevalence of a certain amount of base sediment in all oil fuels, and the relatively small orifice at the tip of the oil burner, care should always be taken to pass the oil through a suitable mesh strainer (about 40 mesh) before firing. Many designs of burners have a strainer fitted within the body of the burner. Whether such is the case or not, independent strainers installed in duplicate should be a part of the system located between the burners and the oil heater. Strainers, so installed, should be cleaned at least once every twelve hours by dipping in kerosene and blowing a steam jet through the mesh to dislodge particles of foreign matter. The frequency of cleaning strainers should be determined by the engineer, based on the grade of oil being fired.

Furnace Lining.

One of the primary functions of the refractory brick furnace lining in a water-tube boiler is that it serves as a medium to radiate heat to maintain the requisite furnace temperature, and assist in the combustion of oil fuel. It is generally an accepted fact that the water-tube boiler is better adapted for the use of oil fuel than the Scotch (fire tube) boiler, due primarily to this very lining, the incandescence of which plays so important a part in the maintaining of adequate furnace temperature. Such brickwork should be of the best quality refractory firebrick capable of standing a continuous temperature in the neighborhood of 3000 degrees Fahrenheit. While less is demanded of the brickwork in a Scotch boiler furnace, inasmuch as its location is limited to the front of the furnace in a cone surrounding the burner, and in certain installations to the junction of the furnace with the combustion chamber, yet it is not good practice to use an inferior grade of brick due to need for more frequent replacement.

In setting up firebrick lining in any type of furnace, suitable allowance should be made for expansion at the joints. A cement wash surface is recommended throughout to serve as a protection to the brick edges and joints, though not essential to proper operation. Any high-grade cement wash will give the desired results on the brick walls, etc. On new walls cement wash should not be applied until the furnace has been thoroughly heated to insure complete drying of bricks and mortar. After the furnace has been allowed to cool until the walls are comfortable to the touch, the cement wash should then be applied. For the bottom, broken glass scattered about will afford a cheap and effective glaze after the furnace has been subjected to combustion, the glass melting, spreading over the floor and filling the cracks.

In Scotch boiler furnaces the firebrick cones surrounding the burners should be kept perfectly round and smooth in order to prevent the flames from striking on any projections and causing smoke. In every case the cone should be a circle concentric with the burner tip. In all types of furnaces the firebrick work should be carefully inspected whenever a boiler is cut out, and all holes patched, cracks filled up, loose brick either replaced or reset, and cement wash renewed.

Rules for the Prevention of Casualties.

In the everyday operation of an oil-fuel burning plant there are certain axiomatic rules which must be adhered to at all times in order that the safety of the plant and its operators may be assured. The term "casualties" is perhaps the most appropriate to apply to accidents which might result directly from the careless handling and burning of oil fuel. In general, they may be confined to explosion and fire. Explosion may be caused by neglected leakage, accumulation of oil vapors in unfrequented places, and flarebacks within the furnace; ignition in the first two cases being caused by contact with a naked flame, flash or spark of some nature. Fire may be considered to be the result of explosion in practically every case. Flareback as a cause of explosion is probably the most general operating casualty to guard against. It may or may not be serious, depending entirely on the extent of the explosion within the furnace, and the amount of explosive oil vapor present in the furnace. In general, it may be said to occur when lighting up, due to the accumulation of oil vapors within the combustion chamber occasioned by leakage from the burner tip.

The most general rules for safe operation are outlined as follows:

1. Do not allow leakage of oil to continue at any point whatsoever in the system.
2. Do not allow spilled or leaked oil to accumulate; wipe up immediately.
3. Do not allow oil vapor to accumulate in a furnace. It is well to blow the latter through with steam or air before lighting off a burner.
4. Do not stand directly in front of a burner when lighting off. It is best to use a torch at least four feet long, and to stand at one side of the burner so that in case of flareback the chances of personal injury will be as slight as possible.
5. Do not relight a burner from a hot furnace wall.
6. Do not leave a burner valve turned on. Should the flame be extinguished through any accidental cause, close this valve immediately, otherwise danger of flareback on re-lighting will be present.

Flue-Gas Analysis.

It is not intended to go into detail in regard to the matter of flue-gas analysis, but rather to touch briefly on the purpose and importance of such tests and the results they should lead to In effect the flue-gas analysis indicates the degree of combustion obtained, i. e., low CO_2 with a high percentage of oxygen and little or no CO indicates excess air. Low CO_2 with high CO indicates incomplete combustion. To obtain good combustion the percentage of CO_2 should be around 14 per cent—and never below 11 per cent; with such percentage of CO_2 the amounts of oxygen and CO will automatically be within the desired low limits.

The installation of a CO_2 recorder is a valuable adjunct or supplement to the flue-gas apparatus. Either or both the above instruments should be part of the plant equipment in order that most efficient results may be obtained. With the installation of a CO_2 recorder, by watching this and the character of the flame, as explained above, the engineer may feel sure that he is following best

practice in the operation of his fireroom. The bonus system is in force in many up-to-date plants, where a definite minimum percentage of CO_2 is specified and a flat rate paid to the fireman thereon. For any saving over this minimum, and for a higher percentage CO_2 gained up to normal limits, a bonus is paid to the firemen who obtain the same.

Standardization of Equipment.

Wherever possible oil-fuel burning equipment should be standardized in order to arrive at the highest general plant economy, and facility for making repairs. The purchase of both original and replacement equipment should be made with a view to ease of installation, adaptability to the plant, ease of obtaining spare parts, cost, and the general reputation of the equipment concerned to do the work required of it.

[R. S. N.]

Chemical Control in the Beet Sugar Industry.*

By S. J. Osborn.[1]

The chemical control of a beet sugar factory may range from almost nothing up to the work performed by a large and highly-complex organization. It is the purpose of this paper to give some idea of the activities of a chemical department of the latter type.

The beet sugar chemist was formerly a poorly paid individual who was expected to do a certain amount of laboratory work with the help of perhaps one or two assistants. He was frequently a man of very limited technical education, and, owing to the fact that a beet sugar factory operates for only three or four months during the year, the chemist was often considered of not sufficient importance to be kept on the payroll after the end of the campaign, or operating season. Naturally this did not conduce to the development of a high grade of work or to the standing of the chemist in the industry.

In some companies of sufficient size the chemical control work is now handled by a specially organized chemical department, entirely independent of the operating department, although the two naturally enjoy intimate relations and must work in close cooperation to achieve the best results. This system has many advantages. Not only does it relieve the operating department of responsibility for a highly technical line of work, but it puts the results on a basis where they are free from even any suspicion of bias or irregularity, and facilitates the introduction and use of uniform methods of analysis and control at all factories of the organization. Naturally it does not pay to develop an elaborate system of chemical control unless the operating and engineering departments are also sufficiently developed to use and apply the data, and the growth of the several departments will therefore go hand in hand.

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* Read at the 59th Meeting before the Sugar Section of the American Chemical Society, St. Louis, Mo., April 12 to 16, 1920.

[1] The Great Western Sugar Company, Denver, Colorado.

Methods of Chemical Control.

While the beet sugar manufacturing process is not a highly complicated one, as chemical processes go, it is doubtful if any other manufacturing process is so closely and thoroughly controlled at every step by the chemical laboratory.

An important factor in the development and application of chemical control in all branches of the sugar industry is the extent to which rapid and reliable control methods have been worked out. The polariscope, which has supplanted the older, time-consuming, chemical methods for the determination of sugar, is the principal and indispensable tool of the sugar chemist, and it is not too much to say that without it the sugar industry would still be in the dark ages.

The Brix hydrometer and the refractometer have similarly proved of great value for the estimation of the apparent dry substance, which, together with the polarization, establishes the "apparent purity," a figure which is a *sine qua non* in the operation of a sugar factory. Many other methods could be described, if time permitted.

To avoid the impression that the laboratory work may be of a wholly superficial character, it should be stated that the rapid methods are used to handle a large volume of work and yield immediate information, but enough work is done by the most reliable methods known to furnish all the fundamental information which is believed to be of value.

Scope of Chemical Department.

In our organization the chemical department has a wider field than its name might strictly indicate. It issues and is responsible for almost all of the important operating reports, other than financial, and keeps a detailed set of records for this purpose. It secures all the necessary data for the calculation of extraction losses. The chemist is therefore responsible for testing the automatic beet scales, for weighing the molasses, and for obtaining accurate records in general throughout the factory. Naturally the laboratory is called on for information and advice in solving the numerous technical problems which arise, and its assistance can be of the greatest value.

The chemical department also accumulates a great mass of data which is of the nature of general information and may not be of immediate application, but nevertheless has a great potential value. In the first place, it furnishes a record of many campaigns' experience by which new technical questions may in many cases be answered and future policies may be decided, and, in addition, it has been our experience that from such data general laws have been deduced which have been of the utmost importance in their application to prevailing conditions. One of the problems of the chemical department is the question of the extent to which work that does not have an immediate application shall be carried out.

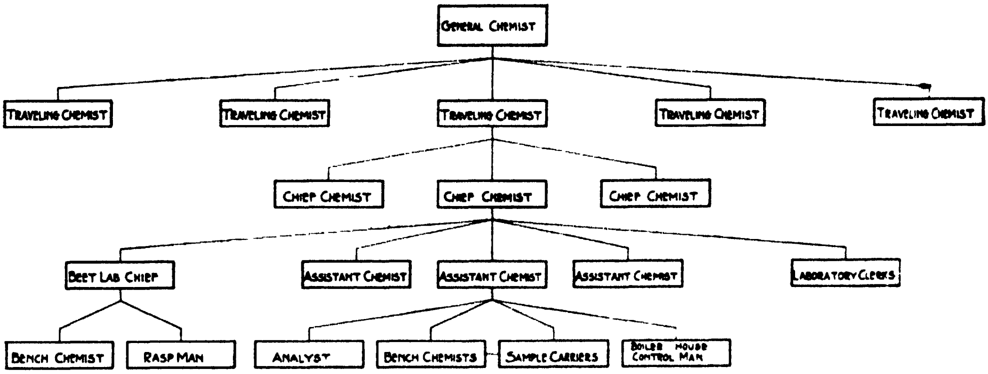
Work of a Chemical Department.

Some figures on the amount of work done in the laboratory of one of our beet sugar factories may be of interest. The amount of work is dependent not so much on the size of the factory as on whether or not it is equipped with the

Steffen process, or with a pulp dryer, or with both. The following statement shows the approximate number of the common tests made per 24 hours in one of our average laboratories:

200–300 Polarizations.
150–200 Apparent purity determinations.
125 Brix determinations (reported).
175–225 Alkalinity determinations on juices.
60 Determinations of CaO by titration on lime cake, lime, etc.
30–60 Determinations of CaO by soap solution.
225 *a*-Naphthol tests on condensed waters.
200 Temperature readings in the factory.

Each factory also maintains a special beet laboratory, the work of which has consisted of from 100 to 500 polarizations per day of beet samples of 25 lbs. each. If the beet growers are paid on a sliding scale based on sugar percentage, as was formerly the case, the beet laboratory tests determine the basis of payment to the farmer. Otherwise the tests are made as a matter of information for the agricultural department, as it is important that it should have accurate data on the quality of the beets, not only as a whole, but also in different districts and at different periods of growth.



Organization Chart

PERSONNEL.

The personnel of the laboratory organization at a single one of our factories varies in number from 22 up to 42, who, with a few exceptions, work in 8-hour shifts. The accompanying organization chart will explain how the work is handled.

The General Chemist is the head of the department. Directly under him are five Traveling Chemists, each of whom has supervision over the work of the department at three or four contiguous factories and has his headquarters at one of the factories with which he is connected. The Chief Chemist, who in turn is responsible to the Traveling Chemist, is the head of the local factory organization and has no routine duties. There are three Assistant Chemists at every factory, one on each shift. The Assistant Chemist has charge of the laboratory employees on his shift, and in addition has a certain amount of analytical work, and work in the factory such as the supervision of the sampling, the test-

ing of the beet scales, reading of meters, etc. The Bench Chemists, of whom there are three or four on each shift, perform the routine tests, while the Analyst takes care of the extra analytical work demanding a higher degree of skill. In some cases the Assistant Chemists handle all of this work and there are no special analysts, while in other cases, where the volume of work is greater, one or two analysts are employed. The Boiler House Control Man collects samples of coal and ashes, makes flue-gas analyses, and secures various data in the boiler house from which a complete heat balance is calculated every day.

The Chief Chemist has charge of the laboratory clerical work, for which purpose two to three clerks are employed; this is by no means a small part of his responsibility. He also supervises the work of the beet laboratory, which has been previously described.

Our customary intercampaign laboratory personnel at each factory consists of the Chief Chemist and one or two Assistant Chemists. From this nucleus there must be built up every year for the campaign work an organization of the kind just described. The beet sugar industry has its peculiar problems and this is one of them. It should be remembered that this organization problem is one that has to be met not once in a long period of time, but is a yearly part of the work to which the Chief Chemist has to look forward. To get a new laboratory organization working smoothly in a short period of time is by no means an easy task and demands a high degree of executive ability in addition to the technical knowledge required.

[R. S. N.]

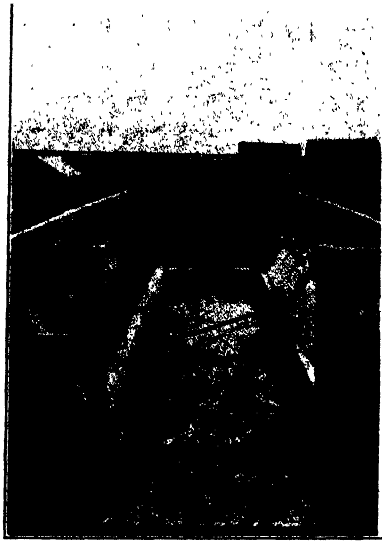
Two Big Feed Economies.*

An Illinois Farmer's Plan.

I have seen a good many plans that were used to save time in feeding hogs, but in some cases I have found that the value of the time saved was more than lost in feed that was wasted. So I worked out two plans which save both time and feed. Both of these plans are pictured on the following page.

In one of the pictures you see the hog troughs being filled. The feed-saving idea shown in this picture is the gate which holds the hogs away from the trough until the trough is filled. This idea is somewhat similar to that used in many hog houses, but still it is sufficiently different to be important. As you will see from the pictures, the hog troughs in each lot are placed with one end to the outside fence. The hog troughs are made of concrete. There is a concrete alleyway between them, and a concrete platform around them. Two troughs for two adjoining lots are made together. The troughs are made higher on one side

*System on the Farm, March, 1920.



Showing Gates in Both Positions.
At the left, the hook holds the gate in place while the feed is poured into the trough. The other trough is accessible to the pigs.

Slop and Dry Feed Without Loss Through Waste.
Concrete and wooden platforms save slop and dry feed from being tramped into the ground. The self-feeder platforms are reinforced by strips of 2-by 4. In the background are sun shades for summer.

than on the other, so that it is practically impossible for the pigs to root their feed out over the top of the trough. That is one feature of the feed-saving plan.

A concrete platform in front of the trough prevents a mud hole being formed around the trough, and if any feed should drop out, it would be caught on the platform and the hogs would later pick it up. Sometimes a hog will take a big mouthful of feed in his eagerness to get his share and drop part of this onto the platform in front of the trough.

One of the biggest wastes in feeding is due to part of the slop being poured onto the heads of the hogs, where it serves no good purpose. This happens because the feeder has to fight with the hogs to get the feed into the troughs. The big gate that swings over each trough keeps the pigs away until the troughs are well filled. The device that controls this gate is a little different from other devices of this sort that I have seen. You can see that it has a hinged metal handle made of two pieces of strap iron. The two pieces are bolted together and the bottom piece is bent as shown in the picture, so that it will hook over the edge of the trough. When it is hooked over the outer edge of the trough the gate is held out of the way so that the pigs can eat. When it is hooked over the inner edge of the trough the gate is held in front of the trough so that the pigs cannot get in. The operation of this device is very simple.

After you have wallowed through the mud in a hog yard trying to feed your pigs, I am sure you will appreciate this plan, especially the concrete floor part. It isn't necessary to change the location of hog lots as it is necessary to change the location of sheep pastures, so permanent equipment like this can profitably be made. There is a drain in each trough so that any water that is left may be readily drained out. Sometimes we wash out the troughs, but they

very seldom get dirty, because there is never a mud hole around them. The pigs' feet are usually clean when they put them into the troughs.

I think the details of this feeding plan are all made plain in the pictures. You can see that the fence around the alley is made of two-inch stuff so that it will be strong enough to hold back the pigs. The hinges on which the swinging gates are mounted are bolted to the gates instead of fastened with screws. This holds them more firmly. It would not take long for the hogs to work the screws loose, but the bolts remain in place no matter how much the hogs work at the gates. The parts of the gate are also bolted to the upright pieces.

I use a barrel cart that permits using different barrels. I have a cover for each barrel so that I may fill it quite full without having the slop spill out. This cover is hinged to the back of the barrel, so that it is never lost or misplaced.

[J. A. V.]

Kudzu.*

By C. V. Piper.[1]

Description of Kudzu.

Kudzu (*Pueraria thunbergiana*) is a large-leaved, woody, leguminous vine, native of Japan. It grows with remarkable rapidity. It thrives well in the eastern half of the United States and survives the winter as far north as Nova Scotia. It succeeds in various types of soil, but usually better where it is clayey than where sandy. Where the summers are warm and moist it grows with great luxuriance. Kudzu is a most excellent vine for arbors and porches, for which purpose it is commonly cultivated in most of the southern cities, under favorable conditions of support climbing to a height of 70 feet or more. The leaves resemble in a general way those of the common bean, but they are larger, angularly lobed, and tougher in texture; the stems and leafstalks are somewhat hairy. As far north as Philadelphia the vine will bloom, but only occasionally, and then late in the summer or early in the fall. The blossoms are purple and hang in short clusters (Fig. 1). The pods are thin, very hairy, and very rarely mature in the latitude of Washington, D. C.

The Japanese utilize kudzu in many ways, growing it especially on rough, rocky land or hillsides too steep to be cultivated and using it for pasture. The fiber of the stems is used largely to make a sort of cloth known in commerce as "grass cloth." Various other articles of utility, such as portmanteaus, are also made from this fiber. The thick roots are rich in starch of a high quality, which is extracted and used for human food, especially to make cakes and noodles. It is said that kudzu in former times played an important part in periods of famine. For starch making the roots are dug after the leaves fall in the autumn and before the buds burst in the spring. The Japanese also make hay from

* U. S. Dept. Agr. Cir. 89.

[1] Agrostologist in Charge of the Office of Forage-Crop Investigations, United States Department of Agriculture.

the kudzu vine, especially to feed to sick horses, as it is said that they will eat this readily when they refuse other food. It is more generally fed green.

Although kudzu has been grown in the United States for many years, at least since 1876, it is only in recent years, owing to the work of Mr. C. E. Pleas, of Chipley, Fla., that interest has been created in it as a forage crop. Attracted by the remarkable luxuriance of the plant and the fact that horses and cows ate the leaves greedily, he cured some as hay, which he found was equally palatable to the animals. He then planted a small field, probably the first of the kind ever established in this country. Under field conditions kudzu sends out long prostrate branches which root at many of the joints, from which arise ascending twining branches, the whole making a dense mass of herbage 2 to 4 feet thick. Eventually, separate plants develop, as the prostrate runners usually die between the rooted joints. Such a field when full grown presents much the appearance of a dense crop of cowpeas, soy beans, or velvet beans.

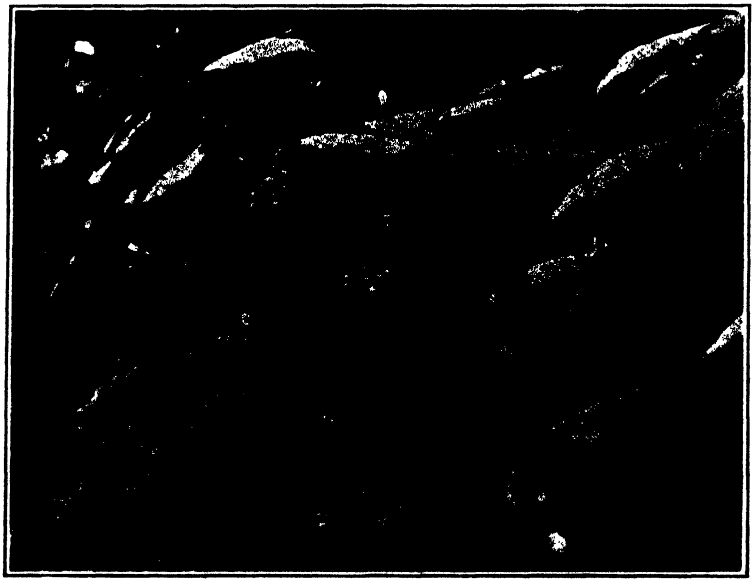


Fig. 1. Kudzu in Bloom.

Kudzu when well established covers the field with a dense mass of herbage. Seeding is too expensive to advise and is generally unsuccessful. Setting the rooted plants in the field where they are to be grown is the best method. The plants, however propagated, are set about 10 feet apart each way in the field. They succeed best if put out very early in the spring. During the first season the trailing runners cover the ground; the second season good crops are secured, but usually the largest crops are not obtained till the third season and subsequently. A crop of corn, soy beans, cowpeas, or peanuts can be grown between the rows of kudzu during the first season and thus avoid losing the use of the land. As kudzu is a long-lived perennial, it is advisable to plant it only where the field can remain in this crop for several years. Young plants are sometimes severely injured by rabbits.

Seed. The seeds of kudzu do not germinate very well. If used, they should be planted in a well-prepared seed bed and the plants transplanted very early in spring after they are well rooted.

Cuttings. Kudzu may be propagated by cuttings, but under field conditions a large percentage fails, so the method can not be recommended. The best success with cuttings has been secured by using well-ripened wood and setting out very early in the spring.

Transplantings. A new field of kudzu is best established by the transplanting of well-rooted plants.

Grazing.

Kudzu may be utilized as pasture, but should not be grazed too heavily; two fields should be provided, to graze alternately. Some farmers allow the crop to grow until the dry season of the fall, when other pasturage is likely to be scant. There is some evidence that continuous light grazing will give more feed than alternate heavy grazing. The crop is best pastured by cattle, as hogs are inclined to dig out and eat the starchy roots; indeed, hogs may thus be used to eradicate a field of kudzu, when this becomes desirable.

Soiling, or Green Feeding.

Kudzu is excellent for soiling, as was shown by the experience of the Louisiana Agricultural Experiment Station. During an extremely dry period the only green forage available was furnished by the kudzu fields.

Hay.

Some fields in northern Florida after becoming well established have yielded three cuttings of hay a season, and yields as high as 10 tons per acre have been reported. In other fields, the total yield has been smaller than that of velvet beans. At Arlington Farm, Va., kudzu was harvested and cured in the same manner as cowpeas and an excellent quality of hay obtained. Curing frames were used also, and if properly cocked kudzu hay sheds rain without the use of any topping material. In fact, some of the hay was left in cocks all winter, and when opened the following spring was in excellent condition; only the outside was brown and weathered, the forage within being of a bright-green color. Kudzu can be cut readily with a mower. The hay cures more easily than most legumes, as the leaves are less juicy.

The first mowing of a field, however, is sometimes difficult, as the first crop is more tangled than succeeding ones. A good device to use in very tangled crops is an old scythe blade fastened vertically to the end of the cutter bar. The first crop produced is also likely to be difficult to rake, as the trailing stems along the ground are still strong; therefore it is often better to use a fork and make piles or rolls not too large to pitch on to a wagon. There is practically no shedding of the leaves in curing.

Feeding Value.

Chemical analyses indicate that kudzu is very nutritious, being comparable to clover and alfalfa. The leaves, however, are considerably tougher. Horses,

cows, and sheep eat the green leaves readily, as well as the hay. The actual value of kudzu as a feed, either for meat or for milk production, remains to be determined by experiment, but there is little doubt that it is high.

SUGGESTIONS.

In view of the limited experience with kudzu, it is wisest first to make an experimental planting of a small area. The plant will probably succeed nearly everywhere in the eastern United States, but it is doubtful whether it will prove to be profitable on high-priced land. If plantings are made, the kudzu must occupy the land for a period of years in order to be profitable.

The Japanese plant it extensively on steep slopes and other untillable land, using it mainly for pasturage. In this country little success has thus far been secured by planting on uncultivated land, but there is need for many more trials of this sort.

[H. P. A.]

THE HAWAIIAN PLANTERS' RECORD

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The "Japanese" Beetle is Chinese.

By F. Muir.

For many years we have called our local pest by the name of "Japanese beetle," believing that it came to us from Japan. This came about through the first specimens that were sent away for identification being identified as *Adoretus tenuimaculatus*, a beetle only known from Japan. Recent investigations have shown that our local pest is not this species, but *Adoretus sinicus*, a beetle known from China, Annan, Formosa, Java, and Timor, as well as Hawaii.

The genus *Adoretus* contains from 150 to 200 species from all parts of the world which are all about the same size and mostly very similar in appearance. It is only by recent anatomical researches that the species have been satisfactorily distinguished and numerous wrong identifications, like our own, rectified. This shows the value of purely scientific research to economic work. For parasitic work it is necessary to know the native home of a pest, and a wrong identification might send a person off to a wrong quarter of the world to search for parasites.

The common species in Japan, *Adoretus tenuimaculatus*, flies and feeds by day and not by night, so I previously concluded that ours had changed its habits since its introduction in Hawaii. Now we know that it is a distinct species, with a distinct feeding habit.

And for our understanding of these things we have to thank the scientific investigator whose only ambition was to find anatomical differences in these insects.

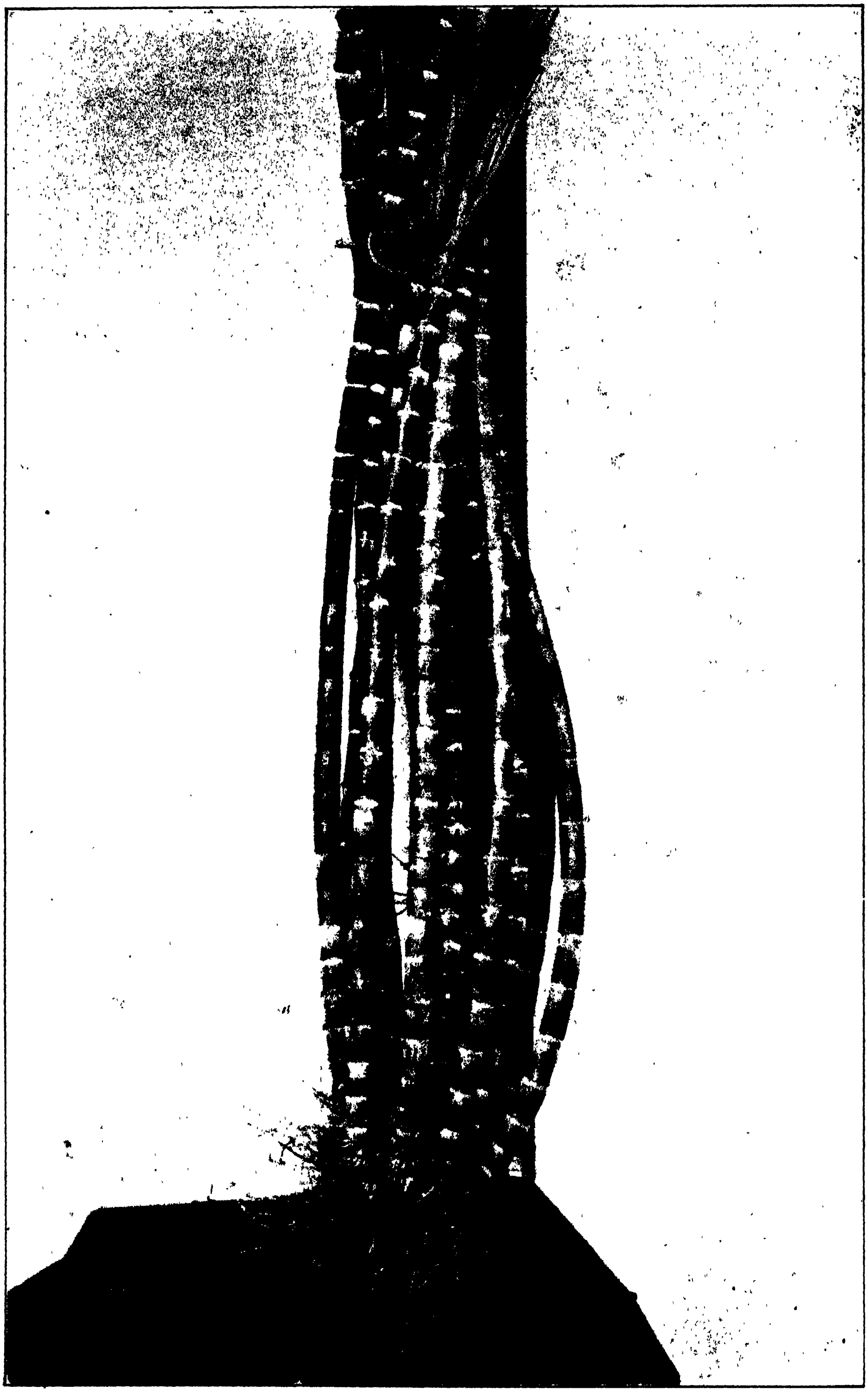


FIG. 1. A cane stool grown from a single seed of H 109.

The Cane Plant.*

By H. L. Lyon.

A cane plant begins its career as a single shoot or culm arising through the germination of a cane seed or the sprouting of a single eye on a cane cutting. As the primary shoot develops, secondary shoots arise through the shooting of the basal eyes on the primary shoot. Stalks of the third, fourth and succeeding categories may arise as part of the same plant through the shooting of the lower eyes on stalks of the preceding category; that is, secondary shoots arise from primary shoots, and tertiary shoots from secondary shoots, and so on.

FIG. 2. Base of stool, showing origin of culms. 1—primary stick; 2—secondary sticks; 3—tertiary stick; 4—point of attachment to seed piece; g.l.—ground level.

On the plantations the term "stool" is commonly applied to any clump of shoots arising together in a compact group or cluster. Such a clump of shoots may include two or more plants, as it may have developed from two or more eyes on one or more cuttings. To be absolutely correct we should use the term "stool" to designate a single plant only.

A cane culm or stalk is differentiated into nodes and internodes. The leaves are attached to the nodes and a single bud or eye occurs on each node in the axil of the leaf. Roots may also spring from the node. The internodes are the smooth, cylindrical or barrel-shaped sections of the stem between the nodes. The internodes carry no appendages or outgrowths.

A cane stalk elongates through growth at its tip only. The inception or creation of new nodes and internodes takes place at the tip or growing-point of the

* A lecture delivered at the University of Hawaii in the "Short Course for Plantation Men."

stem; a new leaf and new bud being formed as appendages of each node. Each new leaf develops as a tightly-rolled tube which pushes its way up inside the tube formed by the preceding leaf; thus each stem carries at its summit a single upright roll or spindle of leaves from which the oldest leaf unrolls at intervals and falling away from the spindle begins its work as a mature leaf.

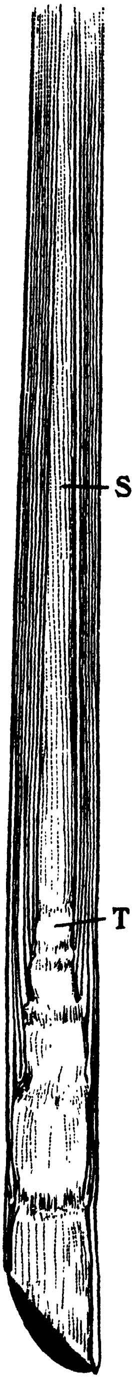


FIG. 3. Spindle of cane, with one side cut away.

A cane plant is anchored in the ground by branching roots which spring from the lowermost nodes of its culms, principally from those buried in the soil. (See Fig. 1.) Cane roots are cylindrical, pointed at their tips and more or less irregularly branched. In burrowing through the soil they meet with many hard obstacles and consequently bend and turn this way and that to get around the hard spots. They may also become very much flattened and distorted in order to enter narrow and tortuous channels in the soil. The younger healthy roots are more or less covered with fine soft hairs known as root-hairs.

While we speak of the nodes and internodes as the two general regions to be recognized on a cane stalk, still there are certain areas within each region which are clearly marked off and which have special functions.

The insertion of the leaf marks the basal end of each node, and we designate this the leaf-node. When a leaf drops off it leaves a narrow flange from the base of its sheath still attached to the leaf-node. This we call the leaf-scar. Just above the leaf-node is a band of tissue with a more or less undulating surface on which slight dome-like elevations mark the position of dormant roots. This is the root-band. Directly above the root-band is a ring of tissue which by enlarging on one side more than the other may cause the stem to bend. This is the stem-node.

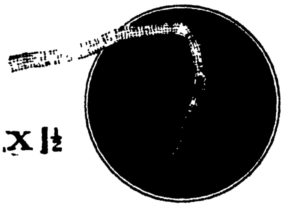


FIG. 4. Tip of root, showing root cap and root hairs.

On each node directly above the leaf-node and extending across the root-band is a single bud or eye. The eye is usually situated in a depression in the root-band, and this depression sometimes extends up into the internode above as the eye-groove. A band of white or grey wax usually extends around the upper end of each internode and is designated the wax-band. This wax is only superficial and may be scraped off without marring the internode.

Two general areas are to be recognized in a cane leaf, the free portion being called the blade, and that portion which closely invests the stem being called the sheath.

The blade is differentiated into a thick central strand, the midrib, and two lateral thin wings which are armed along their margins with sharp teeth. The wings of the leaf are filled with straight veins which run lengthwise of the leaf and quite parallel with each other. The course of these veins is not exactly lengthwise of the leaf, for they really diverge from the midrib, run out obliquely through the wing and

terminate at the margin of the leaf. When we look at the lower surface of the midrib we find that it is packed with veins, and if we follow up these veins we find that sooner or later they diverge from the midrib and pass out into the wing of the leaf. We can follow the veins of the leaf right down into the leaf-sheath, and, in fact, trace them back through its entire length to the stem.

The sheath is attached to the stem at the leaf-node, the line of attachment running a little more than just once around the stem, or in other words the edges of the sheath run by each other or overlap. The leaf-sheath is thickest in its central portion, thinning out toward the margins. The auricle is a very thin tab on the inner or covered edge of the leaf-sheath. It is a more or less useless appendage and may or may not be present on the leaf-sheath. In some varieties of cane, notably Lahaina, the sheath is covered on its outer surface with sharp hairs or bristles.

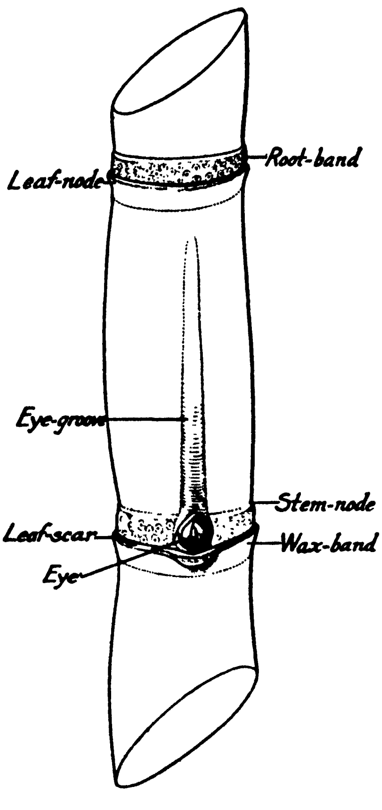


FIG. 5.

The ligule is a thin flap extending across the leaf at the upper end of the sheath. When the sheath is rolled up into a tube the ligule extends around the top of this tube on its inner side. There is usually present a row of hairs at the base of the ligule on its upper side.

The dewlaps are more or less bulging, hinge-like areas between the sheath and the wings of the blade. They usually differ somewhat in color and texture from the blade above and the sheath below. They are often covered with silky hairs on both their outer and inner surfaces when no hairs are present on the sheath below or the blade above. The dewlaps give elasticity to the leaf, permitting it to bend more freely at this point without breaking.

When a cane shoot or culm is about to tassel it ceases to produce leaves and in their place elaborates a flower-spike or inflorescence, a much-branched structure carrying a very large number of flowers. This tassel or arrow is pushed up through the center of the spindle and is eventually elevated well above the leaves, where it expands, opens its flowers and matures its seeds. When a culm flowers it converts its leaf-producing growing-point into a flower spike, and thereafter it can produce no more leaves or internodes and consequently cannot elongate further. Culms which have flowered can only show further growth through the shooting of their buds or eyes. Lalas are the lateral shoots produced through the shooting of the upper eyes on a cane culm. They are of frequent occurrence on culms that have flowered. Their internodes are usually short and hard.

Having noted all of the organs of the cane plant, let us examine the internal

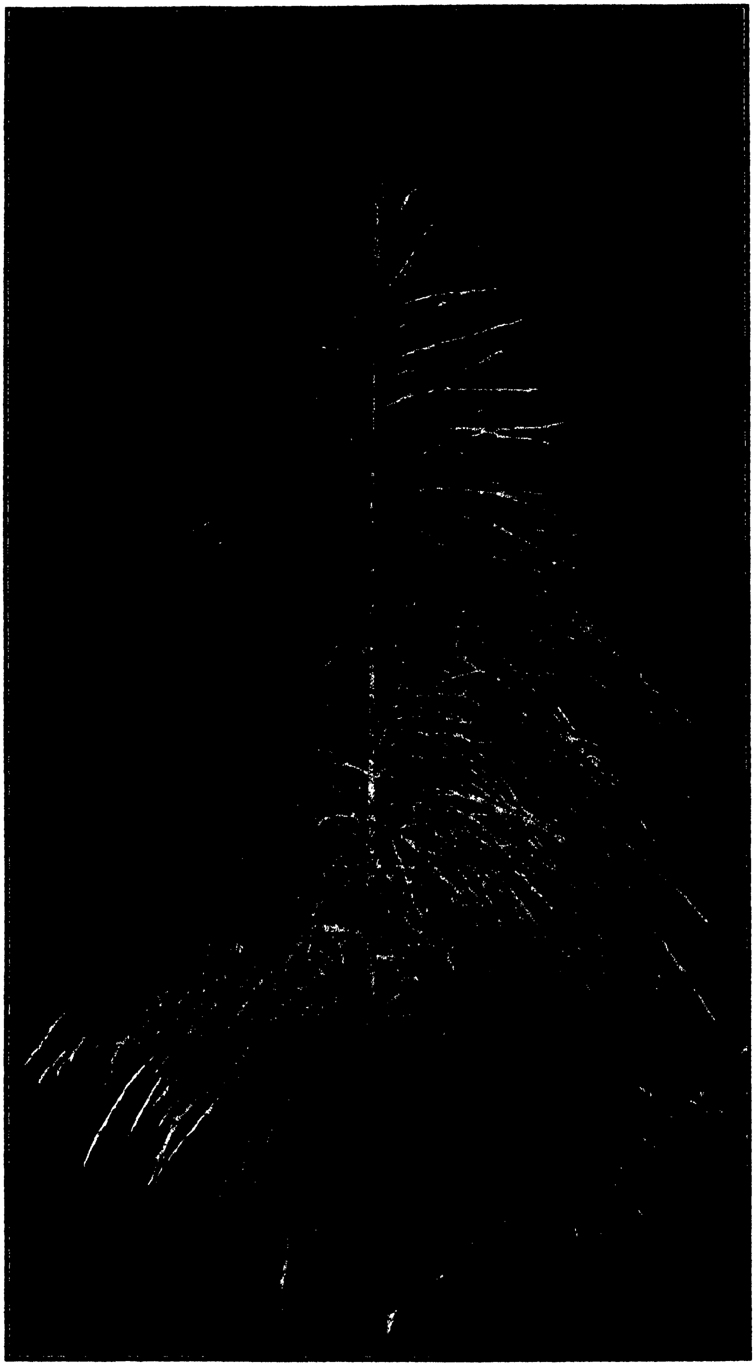


FIG. 6. Tassel of Yellow Caledonia cane.

structure of the more essential organs as far as we can distinguish these structures with the naked eye and a low-power magnifying glass. We will first make a cross-section or thin slice of the stem through an internode, and examine it by holding it up to the light. (See Fig. 8.) In this section we can readily distinguish several areas or kinds of tissue. The rind is the outer hard shell of the stalk. It has to supply strength to support the stem and protection to the softer tissues within. Then there are numerous darker or denser spots scattered all through a white, pithy tissue. These spots are the fibers of the cane in cross-section, and the white pithy tissue is the ground tissue or cortex. It is in the ground tissue that the reserve sugar of the plant is stored, and it is mostly from this tissue that we obtain the sweet juice when we crush the cane. Now let us take a piece of a stick consisting of two or three nodes and as many internodes

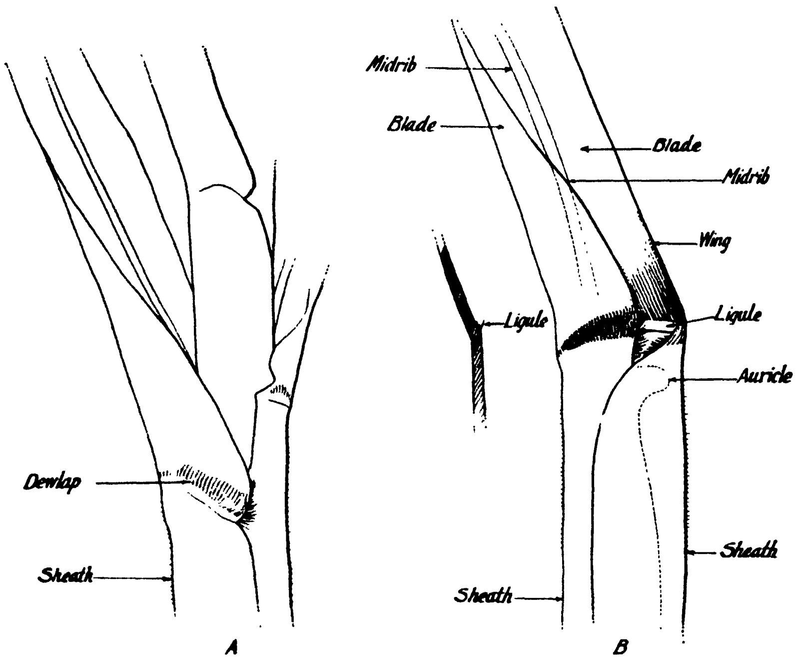


FIG. 7.

and splitting it lengthwise see how these same tissues appear in longitudinal section. In the first place the rind looks very much as it did in the cross-section, and no difference at all can be seen in the ground tissue. The fibers, however, are now seen lengthwise, and we find that they extend as straight strands through the ground tissue of the internode from node to node. In the node they branch, the branches bending one way or another to unite with branches of fibers which extend through the next internode, above or below, or pass outward into the leaf which stands on that particular node. If we examine a leaf-scar we can see the broken ends of the fibers which extended out into the leaf from the stem. If we examine the union of a leaf sheath and stem we can follow these fibers right up through the leaf-sheath and out into the blade of the leaf; they become, in fact, the veins of the leaf. If we were to follow the fibers downward through the

stem we should find that they continue through all the nodes and internodes and finally connect with fibers which run out into the roots.

The fibers constitute the water-conducting tissue of the plant. They enclose water pipes which are commonly termed vessels. In our cross-section we can actually see these vessels as tiny holes in the fibers. When we follow these fibers through the roots, stems and leaves of the plant we are following the course of the water pipes through the plant. This water pipe or water-vessel system is known as the vascular system, "vascular" simply meaning vessel. Supposing we were small enough to get into these water pipes in a cane root; we could then travel upward in these pipes into the stem, and by following the proper branches, go to any node or internode of the stem or out into any vein of any leaf.

The water pipes or vessels have rather thick walls of their own, but they are further strengthened by firm fibrous tissues around them, the resulting strand being called a bundle, and because it contains both fibrous and vascular tissue it is called a fibro-vascular bundle. The fibro-vascular bundles serve two main purposes in the building of the organs of the cane plant; they contain the water-conducting system and they supply strength to the members. In the stem the ground tissue is easily crushed or broken, but it is protected on the outside by the rind and reinforced within by the numerous strands or fibro-vascular bundles. The strength of the leaf is supplied almost entirely by its fibro-vascular bundles.

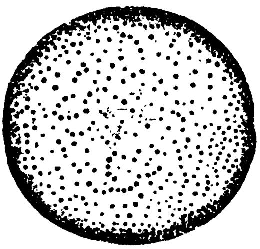


FIG. 8. Cross-section of a cane stalk, showing the distribution of the bundles or fibers.

LIVING SUBSTANCE OF THE CANE PLANT.

The actual seat of life in a cane plant is not in the hard parts of its members—stems, leaves and roots—but in a plastic, semi-fluid substance that lies in tiny chambers within these hard parts.

This living substance is known as protoplasm.

The living substance does not extend throughout the cane plant in one continuous, homogeneous mass, but is divided up into minute masses, each of which lies within a chamber. Because these units of protoplasm reside in individual chambers they are termed cells. The walls between cells are not absolutely solid, but are perforated by infinitesimally small holes through which slender strands of living substance connect the protoplasm of each cell with that of the adjoining cells. In fact, the protoplasm of the entire plant is connected up by living strands; in other words, it maintains telegraphic communication throughout the entire living body.

The walls of the cells are composed of non-living substance which is manufactured and molded into shape by the plastic living substance within.

If we could separate the protoplasm of a cane plant from the non-living substance of the plant without breaking down or otherwise injuring the cell walls, we should have, on the one hand, a shapeless mass of plastic material resembling in consistency the white of an egg; while on the other hand there would remain the stems, leaves and roots of the plant still perfect in form but without life. The hard part of the culms, leaves and roots but constitute the factory building which the living substance of the cane constructs in which to carry on the work whereby it is able to live and perpetuate itself.

The relation which the living substance bears to the non-living substance may be easily understood by considering the sequence of events in a hen's egg during incubation. The freshly-laid egg contains no hard parts whatsoever. It does contain a certain minute quantity of living substance situated on one side of the yolk, while the yolk and white of the egg are concentrated food materials placed there to feed the living substance when it begins to grow and build its own residence or factory, which we call the young chick.

Incubation causes the dormant living substance in the egg to start activities, and it begins to work over the available material, increasing its substance and supporting it by constructing cell walls. At first the cells are pretty much all alike in size and shape, each having only a very thin wall, but as the number of cells increases, some—because of their position and the work which they have to do in the completed factory or body—build thick, rigid walls of very hard material and become bone cells; others, as part of the intestines, build thin walls and assume a shape appropriate to their function. When the egg finally hatches the chick steps forth a highly complex mechanism supplied with bill, bones, nails, etc.—hard parts constructed by the living substance out of the plastic materials contained in the egg. There were no hard parts in the fresh egg, and no hard parts entered during incubation, yet the young chick is supplied with many structures of a firm nature.

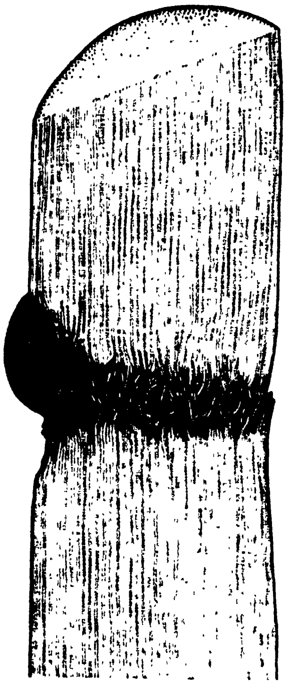


FIG. 9. Longitudinal section of a cane stalk, showing the bundles or fibers.

When we come to study the origin and development of the cane plant in the process of reproduction we shall find that each new cane plant comes into existence as a single cell but without even a cell wall. It begins its life as a naked mass of protoplasm. From the very first it receives only liquid food, and from this food it elaborates additional living substance, increasing its bulk and building cell walls of various shapes and thicknesses, depending upon the work which they must do in the plant body.

GROWTH OF PROTOPLASM.

Now, a cane plant, like every other living thing—plant or animal—sustains its life and adds to its own substance or grows by taking into its system non-living substance and converting it to its own uses, either adding to or repairing its own living substance or building structures (cell walls, etc.) to support and protect its substance.

Protoplasm is made up of a complex of chemical elements in combinations which we are unable to determine, for if we submit it to chemical analysis we kill it and it is no longer protoplasm. We can, however, determine what elements enter into its composition, and these we find to be carbon, oxygen, hydrogen, nitrogen, sulphur, phosphorus, calcium, magnesium, potassium and iron.

To grow, protoplasm must build new protoplasm out of non-living materials. Growth takes place through the building of new living substance out of non-living food materials. Additional protoplasm can come into existence only through the activities of existing protoplasm. Protoplasm is the only force that can create new protoplasm—"Only life begets life."

To build new protoplasm the existing protoplasm must have food containing all of the elements enumerated above. It requires them in very different quantities, however, for carbon, oxygen and hydrogen comprise most of its bulk.

All of the required elements occur in nature either singly or in simple compounds which are practically stable under natural conditions. In the living protoplasm they are put together in various complex combinations and compounds which are more or less unstable, and the protoplasm must do work, and hence expend energy, in order to force these elements together into these compounds.

Growth of the protoplasm is simply a matter of building complex chemical compounds and complexes of these compounds out of the elements or simple compounds. This work is chemical work, and the protoplasm must find the energy to do this work. Where does it get this energy? By simply causing one complex compound to go to pieces and in so doing to give up its energy, which is then used in the building of others. We do much the same thing in a simple way when we burn bagasse, which is a complex of compounds built up by the protoplasm of the cane plant. We cause the compounds in the bagasse to disorganize rapidly into simpler compounds. This releases the energy which was expended in building up these compounds, and we then employ this energy to make steam which operates the machinery in our mills. We release the energy stored up in the bagasse and convert it into mechanical energy which we direct to our own purposes.

When we explode gasoline in the cylinder of an engine, or powder in the barrel of a gun, we release chemical energy stored up in complex compounds, and convert it into mechanical energy. Protoplasm does much the same thing. It causes complex compounds to go to pieces and then employs the energy released; in fact, it may do exactly the same thing, but under better control. It oxidizes compounds and thus obtains energy, but it does it more economically than we do when we burn bagasse, for we always lose a lot of the energy released.

The growth of protoplasm is essentially chemical work, requiring chemical energy to perform, so the protoplasm converts the energy, released by causing one set of compounds to disorganize into chemical energy, and employs it to build up the new chemical compounds and complexes of compounds which constitute living substance or protoplasm.

To grow, therefore, protoplasm must have the elements or compounds required to build up its own substance, and, at the same time, it must have complex compounds to yield energy to do the work. To supply these needs, it must have food which furnishes all these requirements; the material to build with, and the energy to do the building.

The protoplasm of an animal must have complex compounds to begin with. The animal must therefore secure as food the highly organized compounds created by the protoplasm of some other animal or plant. Its only source of energy is in compounds already constructed. The protoplasm of a plant, however, has another

method of turning available energy to its own use. It constructs a green substance which we call chlorophyll. This chlorophyll, when exposed to sunlight, can convert the radiant energy coming from the sun into chemical energy. Chemical energy is thus made available to the protoplasm of the plant and it uses it to construct a complex compound, starch, which constitutes its chief energy-producing food. Starch consists of carbon, hydrogen and oxygen. These elements occur abundantly in nature as water and carbon dioxide. Water is a compound of oxygen and hydrogen, while the air is composed in part of the gas carbon dioxide, which is readily soluble in water. Now, to secure its work-yielding food, the protoplasm employs the energy which it obtains from the sun through its chlorophyll to build up starch out of carbon dioxide and water.

The leaves of a plant are the organs built for the very purpose of making starch out of carbon dioxide and water. In these structures the protoplasm concentrates chlorophyll, and, bringing water and carbon dioxide together in its presence, manufactures starch. Having secured the starch, it proceeds to use it just as the protoplasm of an animal does the complex compounds which it seizes as food but does not itself create.

Protoplasm cannot build new compounds directly out of insoluble compounds. It must have its materials in soluble form before it can work them over under absolute control. The protoplasm of a plant must even get the gas carbon dioxide into solution in water before it can use it in the manufacture of starch.

Now, starch is an insoluble compound, and so are many of the compounds which animal protoplasm seizes as food. In order to get these insoluble compounds into solution so it can use them, protoplasm makes use of certain peculiar substances which we call digestive fluids, ferments or enzymes. These enzymes are non-living chemical tools constructed and operated by the protoplasm. They are of many sorts, for each enzyme can digest only one type of compound. The protoplasm of our own bodies must produce an enzyme to digest milk, another to digest meat, another to digest starch, etc.

Now, when the protoplasm of the cane plant constructs starch it must still digest this starch into a soluble compound before it can use it; in fact, it is in exactly the same position as the protoplasm of an animal that has stolen starch from some plant for its own use. To digest its starch the protoplasm of the cane plant makes use of the enzyme which we call diastase. This enzyme causes starch to change over into a soluble compound, cane-sugar or sucrose, which is the main source of energy as well as of carbonaceous food for the cane plant.

Growth of the protoplasm results from a series of chemical processes controlled by the protoplasm itself. These processes entail the building up and breaking down and building up of compounds in endless sequence. All of these controlled chemical processes are spoken of collectively as metabolism.

In its metabolism the protoplasm of a plant constructs more compounds than it destroys. In its metabolism the protoplasm of an animal destroys more compounds than it constructs.

The plant gets its chemical energy from the sun; the animal gets its chemical energy from compounds manufactured by other organisms.

To live and grow, the protoplasm of the cane plant must have light, air, water and soluble compounds containing nitrogen, sulphur, phosphorus, potassium, calcium, magnesium and iron.

From the light it obtains its energy or power; from the air it secures its carbon in the shape of carbon dioxide; and from the soil it obtains all the rest of its food materials in solution in water.

The body of the cane plant—stem, leaves and roots—constitutes the factory, built by the protoplasm for the purpose of carrying on its life work, which is chiefly a matter of getting food. Its one great problem is to live, and in order to live it must obtain food. The body which it constructs and operates represents its method of working out this problem.

Having selected the conditions of soil, moisture and temperature under which it prefers to grow, it has molded its body structures or organs to do the necessary work under these conditions.

It must burrow in the soil after water and soluble compounds, and so builds roots which are specialized organs to do this particular kind of work. It must expose chlorophyll to the light, and builds leaves specialized to do this work. Then it must have a supporting structure to carry these leaves and hold them up into the light, and it has elaborated the stem or stick for this purpose.

Now, the protoplasm working in the roots must receive carbonaceous food made in the leaves, for it is working in the dark and cannot make starch for itself. The protoplasm in the leaves must receive water and soluble compounds absorbed from the soil by the roots, while the stem must receive materials from both roots and leaves.

In constructing its factory, therefore, the protoplasm must provide means for transporting material from each organ to all other organs of its body. So in addition to its manufacturing operations it has to provide transportation for both crude and manufactured materials.

Let us now see how the protoplasm of the cane plant works out these problems. First of all, we must make a more careful study of the protoplasm itself. Taken by itself, protoplasm is a slimy, viscid, mucilagenous substance, much resembling in color and consistency the white of an egg. Alone, it has no rigidity, and so has to supply rigidity by building a meshwork of firm walls through its substance. In so doing it distributes itself in small chambers or cells, the portion in each cell being a more or less independently operating unit. The protoplasm in all the cells is connected by fine strands and works together for the common good, but the work done by each cell must depend upon its position in the plant body: the cells in a root cannot do the same kind of work as the cells in a leaf, and vice versa.

To study the workings of the protoplasm of the cane plant we must therefore first examine the structure and workings of a cell.

The protoplasm in a cell is differentiated into two essential areas, the nucleus and the cytoplasm. (Fig. 10.) The nucleus is a highly complex structure separated off from the cytoplasm by a thin membrane. The nucleus is the controlling and directing center of the cell, while the cytoplasm is the portion in which the chemical operations are performed. A cell may be likened to a chemical laboratory in which the nucleus is the chemist and the cytoplasm the chemicals and apparatus.

If a portion of the cytoplasm is destroyed the nucleus may, by operating the remaining cytoplasm, construct new cytoplasm and repair the damage; but if the nucleus is destroyed, the cytoplasm is helpless to do anything but disintegrate, go to pieces, die.

In addition to the nucleus and cytoplasm, which are alive, there is always present in the cell a considerable amount of water containing soluble compounds; this is known as the cell-sap. Protoplasm, when active, always keeps itself bathed in water; as a matter of fact, it cannot operate unless it does have a large amount of water at its immediate disposal, and the protoplasm in each cell keeps a supply on hand as the cell-sap. In this cell-sap it holds soluble materials which it may use as food or which it has manufactured and wishes to store up or pass on to other cells.

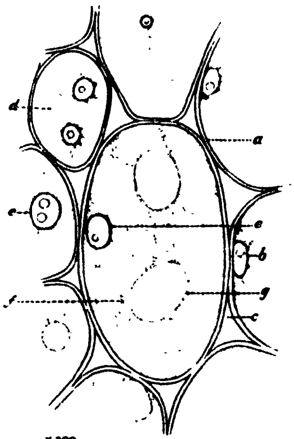


FIG. 10. A plant cell. a—cell wall; b and e—nuclei; c—intercellular air space; d—cell with two nuclei; i. e., caught in division; f—protoplasmic network; g—vacuole containing cell sap.

Besides operating with chemicals in its cytoplasm, the nucleus also constructs and manipulates conspicuous apparatus which is useful in its work. This apparatus takes the form of small, more or less rigid bodies which we call plastids. The protoplasm of plants uses plastids for several purposes, but that of the cane makes extensive use of them in one operation only, and that is in the manufacture of starch. The green coloring matter or chlorophyll is held within plastids which are called chloroplastids or simply chloroplasts. (Consult Fig. 16.) The chloroplasts of the cane plant manufacture starch which is converted into sugar and used as food by the protoplasm of the cell in which it is produced or sent on to the protoplasm of other cells for immediate consumption or for storage for future use.

The cane plant stores its surplus food as sugar, but many other plants store it as starch. Starch is an insoluble material and consequently is not as easily lost as sugar.

The protoplasm of the Irish potato manufactures starch in the cells of its leaves in exactly the same manner as does the protoplasm of the cane plant; and in exactly the same manner it converts this starch into sugar and transports it to other parts of its body. The surplus sugar is not stored as sugar, however, but is converted back into starch again in underground stems or tubers by other plastids which work in the dark. These plastids are called leuco-plastids, and the protoplasm gets energy to operate these plastids by releasing some of the energy locked up in the complex compound, sugar.

Fortunately for us, the protoplasm of the cane plant does not employ leucoplastids, but stores its excess food in the form of sugar.

The cell walls which give rigidity to the plant body and protection to the protoplasm, are composed of a substance, cellulose, which has exactly the same composition as starch. It is, of course, derived from starch, being built up out of the materials supplied to the protoplasm through the conversion of starch into sugar by the enzyme diastase. Like starch, cellulose is composed of carbon, hydrogen and oxygen; and, furthermore, these elements occur in exactly the same proportions in both compounds. However, the elements are put together in a different manner, for there are many and decided differences between starch and cellulose. The latter is more compact and a far more permanent compound than the former. Our own protoplasm can digest and use starch as a food, but it cannot digest and use cellulose to any extent whatever.

We are familiar with starch as corn starch, potato starch, etc. Cotton fiber and, consequently, cotton cloth, are almost pure cellulose.

The cell walls around the living cells in the cane plant, so long as they remain of pure cellulose, are saturated with water, and water or cell-sap may soak through the walls between the adjacent cells, so soluble materials like sugars may readily pass through the walls; in fact, this is the very way in which sugars and other soluble compounds are passed about in the plant; they simply go through the cell walls much as cane juice goes through a piece of filter paper.

Their passage through the cell walls is not a mere physical matter, however, like the passage of the cane juice through the filter paper, for the movement of soluble materials in and out of a cell is controlled to a large extent by the protoplasm in that cell.

The protoplasm of a cell always disposes itself as a layer completely covering the inside of its cell or chamber. At every point a layer of protoplasm lies between the cell sap and the cell wall. The passage of cell sap in and out of the cell is regulated by the protoplasm which may accelerate or prevent its passage.

At many points in the plant body there are cell walls through which the protoplasm does not wish water to pass under any circumstance. The walls forming the very outside covering of the stem and leaves are of this nature, and the protoplasm makes them practically impervious to water by impregnating their cellulose with a substance, cutin. Then, at other points, it wishes to create stronger walls than those of pure cellulose, and it does this by impregnating their cellulose with a substance, lignin. Cell walls which have been impregnated with lignin we say are lignified. Wood is lignified cellulose.

GROWTH OF THE CANE PLANT.

We have found that the protoplasm of the cane plant is organized as an aggregation of cells, each cell being a working unit in the organization. There is, to be sure, a co-ordination of all the cells, all working together for the common good. But the cells in different organs must do different kinds of work and are necessarily different in some respects. Cells doing a common kind of work are usually quite similar, and work together in a harmonious group. Such a group of cells is spoken of as a tissue.

As the protoplasm grows and produces new organs and new tissues it must create these new organs and new tissues by organizing new cells. For each new cell it must have a nucleus and cytoplasm. We have already found that new protoplasm only comes into existence through the activities of existing protoplasm, so it follows that new cells are created only by existing cells, and new nuclei by existing nuclei.

In normal growth of the cane plant new cells are formed through the division of existing cells and new nuclei through the division of existing nuclei. The nucleus is itself a very complex structure. When a cell is about to divide, the nucleus first divides its materials into two exactly equal parts. Each part then organizes itself as an independent nucleus. The two daughter nuclei thus formed move away from each other and proceed to build a cell wall between themselves, dividing the old cell into two chambers. Each nucleus retains about half of the cytoplasm in its own cell.

Many of the cells in the cane plant early lose the power to divide. We know that the older joints of the stem do not elongate, and the leaves do not increase in size after they have unrolled from the spindle. When these structures cease growing their cells have ceased to divide. Their protoplasm may be working, and, in fact, does work until it becomes exhausted and dies; but it does not increase its own bulk and produce new cells by division. Such cells which have ceased to divide and have settled down to one kind of work are known as permanent cells, and the tissues which they comprise are known as permanent tissues.

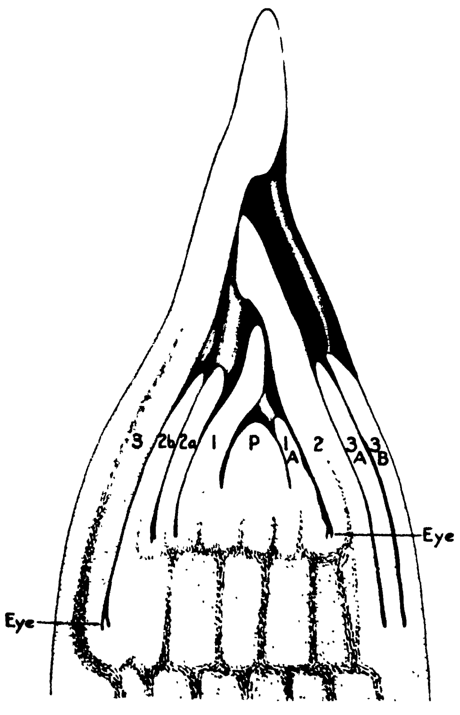


FIG. 11. Vertical section of the tip of a cane stalk. 1, 2 and 3—the three youngest leaves. P—growing point.

The growth of the protoplasm and the production of new cells and new tissues takes place, for the most part, at the tips of the stems and roots. Here we find masses of thin-walled cells more or less alike, which are growing and constantly dividing. These cells are called embryonic cells, since they are capable of further growth and division, and a group of these cells is spoken of as embryonic tissue. Since these embryonic tissues are located at the tips of the stems and roots, they are usually alluded to simply as the growing points.

The embryonic tissue comprising the growing point of the stem is hemispherical or dome-shaped. (Fig. 11.) It increases in size through the rapid growth of the protoplasm within and the constant division of its cells. As it enlarges the outer edge grows more rapidly than the center, and this causes the formation of a ridge around a small central dome. This ridge is not a complete circle, but has two

ends which overlap or run past each other. Now this ridge rises very rapidly as a plate of tissue which is rolled up with its edges overlapping, forming a veritable tube. As soon as one ridge has been formed on the growing point and begins to push up as a tube, the dome again enlarges and another ridge is formed, which in turn pushes up as a tube just inside of the tube developed from the previous ridge. At the growing point of the stem this process goes on, ridge after ridge being formed and each one developing into a tube which pushes up inside of the previously-formed tube. These ridges are the embryonic leaves. They are formed one after the other at the growing point of the stem, the youngest leaf being always on the very inside of the roll and protected by all the leaves previously formed which remain rolled up in the spindle. At first the leaf is composed of embryonic tissue only; all of its cells grow and divide. But as it elongates the cells begin to take on special shapes according to their position in the leaf, and by the time the leaf is exposed to the air and light through the unrolling of the leaves outside of it, its cells have become permanent cells, organized into permanent tissues.

Now, while the growing point of the stem is elaborating new cells and producing the ridges on its upper surface, which develop into leaves, it is also forming new cells which are added to the tissues of the stem. In fact, the growing point forms new cells throughout its entire extent, some being molded into leaves, while others are organized into nodes and internodes which are added to the stem. For every leaf rudiment that is formed the growing point lays down tissue which is later transformed into the corresponding node and internode of the stem. As the rudiments of the leaves grow and assume their permanent shape in the spindle, the nodes to which they are attached also grow and assume their permanent form. All of the tissue in the leaf eventually becomes permanent tissue, incapable of further growth. Most of the tissue of the stem soon becomes permanent tissue also, but a small amount is always held as embryonic tissue. When each node is formed a small amount of its tissue is retained as embryonic tissue and transformed into a miniature growing point. This growing point produces a few scale-leaves to protect itself and then becomes dormant; that is, it stops growing—goes to sleep, and remains asleep until conditions arise which cause it to grow again. These dormant growing points are the buds or eyes, and we know that they must contain dormant growing points of stems, for when we plant cuttings these eyes shoot and produce new stems.

In addition to the growing points in the eyes there are small masses of tissue in each root-band which remain embryonic. These masses are located directly beneath the rind and their position is marked by little mounds or pimples on the surface of the root-band. Under favorable conditions these masses of embryonic tissue will begin to grow, and pushing through the rind become the growing points of roots. And right here let us examine the growing point of a root. A healthy cane root is more or less pointed, and in growing it drives this point into the soil. Now, this is pretty rough work, and no delicate embryonic tissue could stand it. The root has no appendages like leaves to protect its growing point, and so it has to gain protection by producing a special protecting organ, the root-cap, which it pushes ahead of the growing point. To understand the exact posi-

tion of the embryonic tissue in the point of a cane root we only have to refer to the accompanying drawing (Fig. 12), which represents a longitudinal section through the very center of the root tip. The embryonic tissue is located at the point marked (m). This tissue grows, adding new cells to the root-cap (rc) ahead of it and building new tissues onto the body of the root behind it. As the root pushes into the ground the surface of the root-cap may be worn and injured

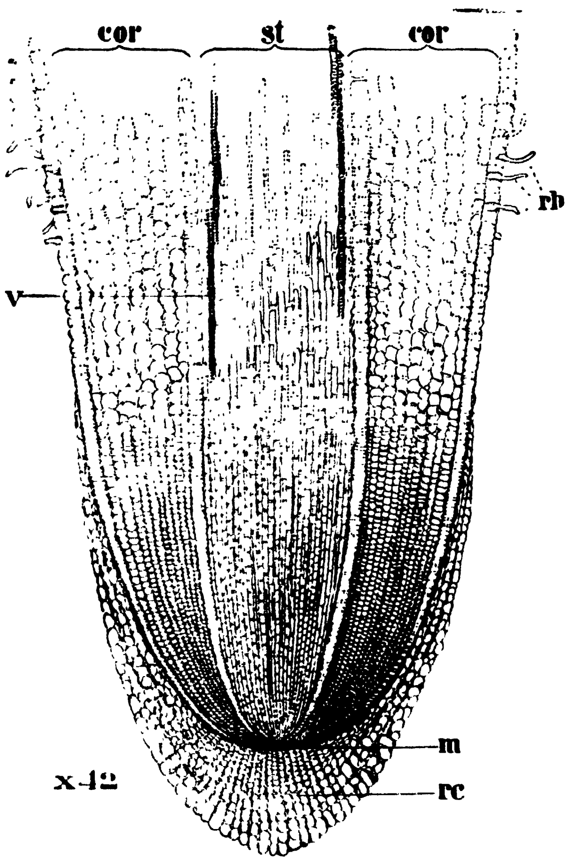


FIG. 12. Longitudinal section of the root tip. cor—cortex; st—central cylinder; rh—root hairs; v—vascular tissue; m—growing point; rc—root cap.

through contact with hard objects in the soil, but as the surface wears off, the cap does not become thinner, for it is constantly being added to on the inside through the activities of the cells at the growing point.

The tissues of the root become transformed into permanent tissues only a short distance back of the growing point—that is, most of the tissues do—but there are always a few layers of cells extending clear around the root and some distance beneath the surface that remain embryonic or capable of further growth. At various intervals there will be organized in this embryonic tissue new growing points of roots. These will start to grow, force their way right through the tissues lying outside of the embryonic area, and push their way into the soil as lateral roots.

The growing point of the stem is at the surface, and new leaves and new stems always arise as outgrowths from the surface, but the growing point of the root is always covered, and new roots always spring from tissues lying beneath the surface. This is as true of the roots that arise in the stem as it is of the roots that arise within other roots. Examine young roots springing from the root-band on a cane stem. Are they outgrowths of the surface or do they push out from beneath the surface? The embryonic tissues at the growing points of the stems and roots of the cane plant are not food-making tissues; in fact, they must do their work in the dark and consequently cannot manufacture starch. Their function is to grow and add to the permanent tissues, and their protoplasm is fed on liquid food which is manufactured by protoplasm in the permanent tissues and then handed on from cell to cell until it reaches the protoplasm in the growing points, where it is elaborated into new protoplasm, which is in turn organized into new cells and new tissues.

PERMANENT TISSUES OF THE CANE PLANT.

Now we are ready to study the permanent tissues of the cane plant, and to do this profitably we must bear in mind how they come into existence and at the same time consider the functions of the various tissues; that is, the nature of the work which each tissue performs. To understand the structure of the factory which the protoplasm of the cane plant builds we must visit the factory in the process of construction and in operation.

The cane plant has three great tissue systems: (1) the tegumentary-tissue system, which is the outside covering of all members. It is the integument or epidermis which forms a continuous covering of all organs—stems, leaves and roots. (2) The vascular-tissue system, which includes the fibro-vascular bundles extending throughout all members, and (3) the ground-tissue system, which begins just within the tegumentary tissue and surrounds and encloses the vascular-tissue system.

These three tissue systems are added to by all actively-growing points; they are added to at the tip of each culm and at the point of each growing root.

At the growing point the cells are all alike, but as cells are pushed off from the growing point into leaves, stems or roots they soon begin to modify their shape and to construct cell walls according to the work which they must do in the members to which they have been assigned. They leave the growing point as raw recruits but are soon marshalled into companies and battalions and equipped according to the duties which they must perform in the campaign. These companies, battalions and regiments are the tissues, their members are living cells which were exactly alike when they marched away from the growing point.

Let us examine a root first. The three tissue systems become evident a very short distance away from the growing point. The outermost layer of cells forms the tegumentary tissue or epidermis, and some of its cells soon grow out into long slender tubes, the root-hairs. The vascular tissue-system of the root consists of but one large vascular bundle which is often called the central cylinder

or stele. (Fig. 13.) The cells in this central cylinder change their shape very quickly. This change is most marked in the direction of the axis of the root; that is, the cells very soon assume the shape of long tubes. The cells, which are in direct line with the existing vessels, quickly build thick lateral walls and then break down their end walls and thus add their length to the vessels or water pipes. In this way the vessels are built onto at their ends, the construction of vessels or the extension of the water pipes closely following the growing point. There are two types of vessels constructed in the stele; small vessels which are quickly constructed and hence extend pretty well up to the growing point, and larger vessels

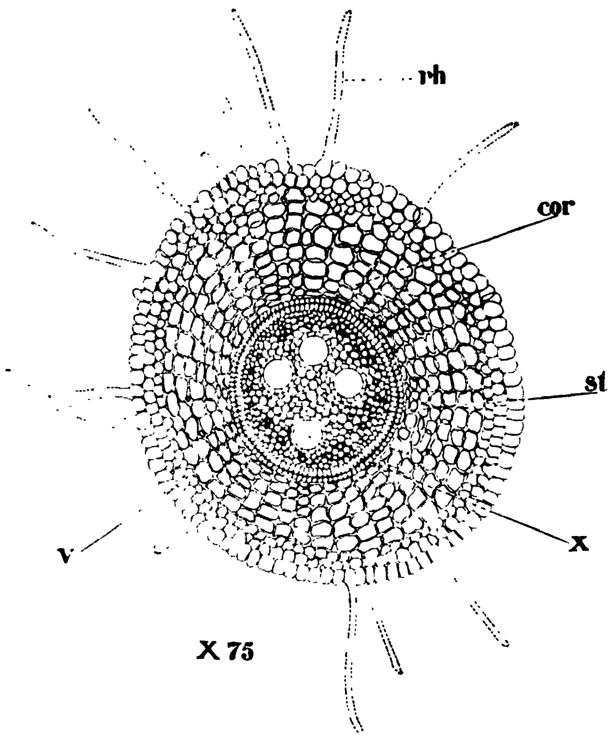


FIG. 13. Cross-section of the root tip. cor—cortex; st—central cylinder; rh—root hairs; v and x—vascular tissues.

which are built somewhat more slowly and hence do not extend as near the growing point as do the smaller ones. To understand the origin, nature and position of these structures compare figures 12 and 13. When a cell is added to a vessel the protoplasm of that cell dies and disappears. The bit of living substance has done its work and it is promptly sacrificed for the good of the plant.

The cells which enter into the ground tissue system enlarge very much but do not change their proportions to any great extent; their protoplasm remains alive and usually includes a large amount of water or cell-sap within its cell wall.

Now, how does a root work? It burrows in the soil after water containing the substances in solution which the plant must obtain from the soil. The protoplasm in the thin-walled root-hairs is particularly well situated to pull in this

water through its cell walls. It then hands it on to the cells in the cortex or ground tissue, which in turn pass it on to the cells in the stele. The protoplasm in these cells then forces it into the vessels. Now, these vessels communicate with all parts of the plant, and the protoplasm at all points above in the stem and leaves may pump water out of the vascular tissue system. The roots must absorb enough water and pump it into these vessels to supply the needs of all the protoplasm throughout the plant.

The growing point of the stem gives rise to the three tissue systems in much the same way as does the growing point of the root, but the resulting permanent tissues are much more complicated. The tegumentary tissue system is developed from the surface layer of cells of the growing point. It extends in one continuous layer over all the leaves, nodes and internodes. The vascular tissue in the stem is not differentiated as a single central cylinder as in the root, but as many cylinders or bundles. We have already noted the position of these bundles in the mature stems and leaves. Now, when the nodes and internodes are being differentiated out of the embryonic tissue derived from the growing point, those cells which happen to be in the course where the vascular bundles should run are constructed into vascular bundles. A short distance back of the growing point the cells which are to become a part of a vascular bundle begin to elongate, and a little further away from the point those cells which are to become vessels can be distinguished because they are forming the thick walls characteristic of vessels, while still farther back the completed vessels may be found in working order. If we pick up a completed fibro-vascular bundle in the stem and follow it up towards the growing point, we will first come to a point where vessels are just being put into commission, then above these we will find vessels in the course of construction; a little further up no vessels can be distinguished, but a bundle is still marked off because its cells are longer than the surrounding cells of the ground tissue; then as we approach the growing point this difference is no longer apparent, the cells being all alike.

The protoplasm of the cane plant extends the vascular system by building new tissues onto the ends of the existing bundles. It takes for material the cells that lie in the path where these vascular bundles should run.

The same thing happens in the building of the leaf. The young leaf is all embryonic tissue. The protoplasm extends the vascular tissue into the leaf by simply making vascular tissue out of those cells which lie in the course where vascular tissue should run.

All the tissue lying inside of the tegumentary tissue system or epidermis of the stem and leaves and not used in making vascular tissue becomes ground tissue. Just as the tegumentary tissue of the leaf is continuous with that of the stem, and the vascular tissue of the leaf is continuous with the vascular tissue of the stem, so also is the ground tissue of the leaf continuous with the ground tissue of the stem. Most of the cells in the ground tissue build only very thin walls and they are prone to pull their walls away from the walls of their sister cells, thus leaving small spaces which may be filled with air. These spaces are known as intercellular spaces. (Consult Figs. 10, 15 and 16.) These intercellular spaces communicate throughout the ground tissues and permit the circulation of air through these tissues. In this way air, which is of course part oxygen, is made readily avail-

able to the protoplasm, and it takes it in and uses it to oxidize complex compounds and release their energy. To understand the origin and relation of the tissue systems of the leaf and stem, make a careful study of the diagram, Fig. 11.

Now that we know how the tissues come into existence, let us examine more critically the permanent tissues, keeping in mind the work which they do in the body of the cane plant. We can best begin with the fibro-vascular bundle.

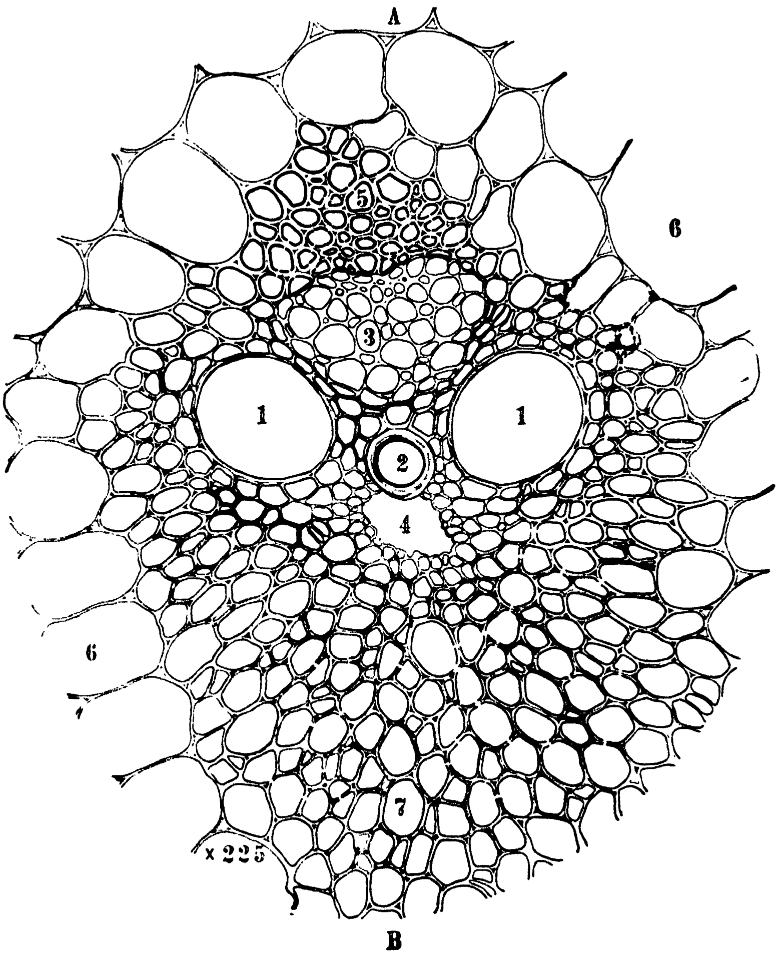


FIG. 14. Cross-section of a fibro-vascular bundle of the stem. 1—two large vessels; 2—an annular vessel; 3—a sieve tube; 4—air space; 5 and 7—thick-walled cells of the fibrous tissue; 6—thin-walled cells of the ground tissue.

Fig. 14 shows the arrangement of cells in a fibro-vascular bundle of the stem as seen in a cross-section of the bundle, and Fig. 15 represents a longitudinal section through the same bundle from A to 4. There are two large vessels marked 1, and one small vessel marked 2 in Fig. 14. 2 is a primary vessel, such as we noted in our discussion of the formation of vessels in the stele of the root. It is finished and working before the protoplasm can get the larger vessels 1 and 1 in commission.

The walls of the vessels are always very much thickened and reinforced with a lining which, in the primary vessels, always takes the form of rings or spiral bands (Fig. 15, V), while in the larger, secondary vessels this lining is always a meshwork much resembling in structure some of the patent screens now in use in sugar centrifugals. The walls of the vessels are also impregnated with lignin, which gives them greater strength than though they remained pure cellulose.

The tissue at 3 in Fig. 14 is the so-called sieve-tissue, which we have not previously mentioned. It is a type of conductive tissue the elements of which are called sieve-tubes. These sieve-tubes are very long, slender cells which stand end to end, very much as the cells do which become vessels. (See Fig. 15.) The cross-walls between sieve-tubes, however, do not entirely break down, but they become perforated with many small holes, and thus form a sieve or sieve-plate. Accompanying each sieve-tube is a long, slender cell which is just as long as its sieve-tube. This cell is called the companion-cell. It always contains a nucleus and cytoplasm, and it would appear that the companion-cell engineers the operation of its sieve-tube, for the sieve-tube, like a vessel, loses its protoplasm as soon as it is completed, and it is operated by the rest of the protoplasm of the plant as part of its transportation system. The protoplasm moves a rather viscid mass of material through the sieve-tube tissue. This material has the consistency of thick molasses. It may contain considerable sugar, but it also contains gums and other more or less insoluble compounds manufactured by the protoplasm but moved with difficulty through solid walls by diffusion, in the way that the readily soluble sugar is moved.

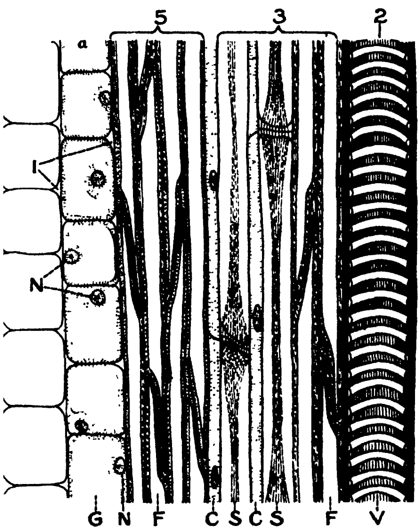


FIG. 15. Longitudinal section of a vascular bundle of the stem; 2 and V—annular vessel; 3 and S—sieve tube tissue; 5 and F—fibrous tissue of thick-walled cells; C—companion cells; N—nuclei; G—ground tissue; I—intercellular spaces.

Now, referring again to Fig. 14, all the tissues of the fibro-vascular bundle, other than the vessels and the sieve-tissue—that is, the tissue at 1, 2 and 3—is fibrous tissue, made up of long, pointed cells, with very thick walls and narrow cavities. These cells are marked F in Fig. 15. Their function is to give strength to the bundle. This fibrous tissue is called sclerenchyma. In Fig. 14 the cells of the ground tissue which directly surround the fibro-vascular bundle, are marked 6, and in Fig. 15 they are marked G. Note their relatively thin walls and the numerous inter-cellular spaces between them.

Now we come to a consideration of the structure of the leaf, which is by far the most complicated organ of the cane plant. It is the most complicated because its tissues are the main manufacturing center of the plant.

All of the raw materials are carried into the leaves and there worked over and converted into the refined products, which are carried to all parts of the plant to nourish the protoplasm. By the time a leaf unrolls from the spindle all of its

cells have been converted into permanent cells. Every one of them is assigned to some kind of work and none is allowed to remain embryonic; consequently, the leaf cannot grow any further; it cannot replenish worn-out tissues. It works hard if it can get the materials to work on, and in a comparatively short time becomes exhausted and dies, the work being carried on by the younger leaves, which are constantly being constructed and put into commission by the plant.

We are already familiar with the chief chemical task which is imposed upon the tissues of the leaf; this task being the manufacture of starch and its conversion into sugar. For this work it sets aside special tissues, the cells of which construct and operate chloroplasts and diastase.

In addition to its chemical work, the protoplasm of the cane leaf has certain important mechanical and physical problems to solve. The leaf is formed in a tightly-rolled tube, and it must be so constructed that it can unroll itself from the spindle when its turn comes. Then, as a mature leaf, it must support its entire blade, swinging free in the air while it is attached at the end only. To do this it must have strong tissues properly arranged to give the necessary support. Finally, the leaf must serve as a boiling-house or evaporator.

We have already noted that the cane plant secures a large number of elements from the soil, these being taken up in solution in water. Now, the soil-solution is always very weak, and in order to get the required amount of each element, the plant must concentrate this solution by evaporating off the excess water, just as we concentrate cane juice to syrup by evaporation. To facilitate this evaporation of water, the leaf is so constructed as to permit of a rather free circulation of air through its tissues. A mechanism is provided, however, whereby the protoplasm may control the ventilation so as to regulate evaporation. If the supply of water coming up to the leaf is meager, evaporation is reduced to a minimum; but if the supply is bountiful, the evaporator is worked at full capacity

Circulation of air through the tissues of the leaf also makes readily available two gases very essential to metabolism in the protoplasm of the plant. These gases are carbon dioxide and oxygen, both always present in the air. The carbon dioxide is absorbed and employed in the building of starch by the cells containing chloroplasts. The oxygen is used to oxidize or burn up compounds in order to release the chemical energy locked up in them.

Now, by referring to Fig. 16 we can get a pretty good idea of the complexity of the mechanism which the protoplasm, assigned to a leaf, builds in order to do the work required of a leaf.

The tegumentary tissue consists of a single layer of cells, the epidermis, extending over both surfaces of the leaf. The outer walls of the epidermal cells are very much thickened, and besides, are impregnated with cutin to render them impervious to water. Very little evaporation takes place through these walls. At intervals in the epidermis on the upper surface of the leaf there occur very large cells, as pointed out at 1, 3, 17 and 18 in the figure. These are known as motor cells, and in co-operation with certain large cells in the ground tissue, as 4 and 5, they cause the leaf to unroll and roll up by swelling or collapsing. When the leaf unrolls, these cells swell by simply filling up with water. As long as the leaf

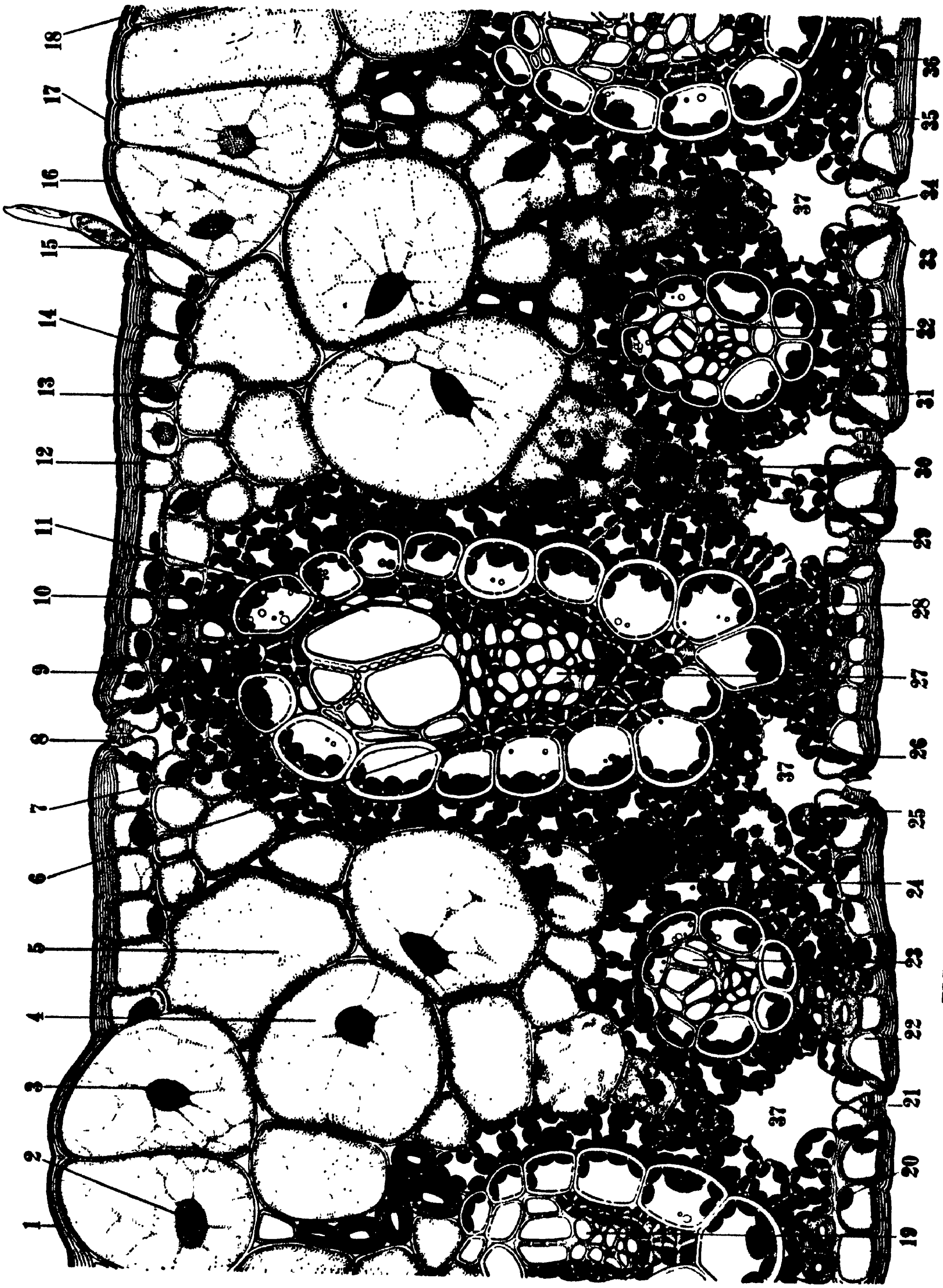


FIG. 16. Cross-section of a part of a cane leaf. For explanation see text.

is supplied with ample water they remain full and the leaf remains flat. If the water supply is deficient they lose water and collapse, causing the leaf to roll up again. A young leaf severed from a cane plant on a warm day quickly loses sufficient water by evaporation to cause it to roll up.

Ventilators or air pores occur in the epidermis on both sides of the leaf, but are much more numerous in that of the lower side (21, 29, etc.). These air pores, or stomata as they are called, are mere slits between two sausage-shaped cells known as the guard-cells. Each guard cell has a lip which may fit tightly against that of its companion, completely closing the air pore. If the guard cells are full of water they hold the lips apart and thus permit air to pass in and out of the leaf tissues, causing rapid evaporation of water. If the guard cells lose their water more rapidly than it is supplied to them, they begin to collapse and their lips approach each other, reducing the size of the opening and thus cutting down circulation and likewise evaporation. If the supply of water coming to the leaf is seriously curtailed, the guard cells collapse to a point where the stomata are completely closed. The opening and closing of the stomata is regulated automatically by the water supply; while there is an abundance of water they remain wide open, but they are very sensitive, and promptly reduce circulation if there is any curtailment of the water supply.

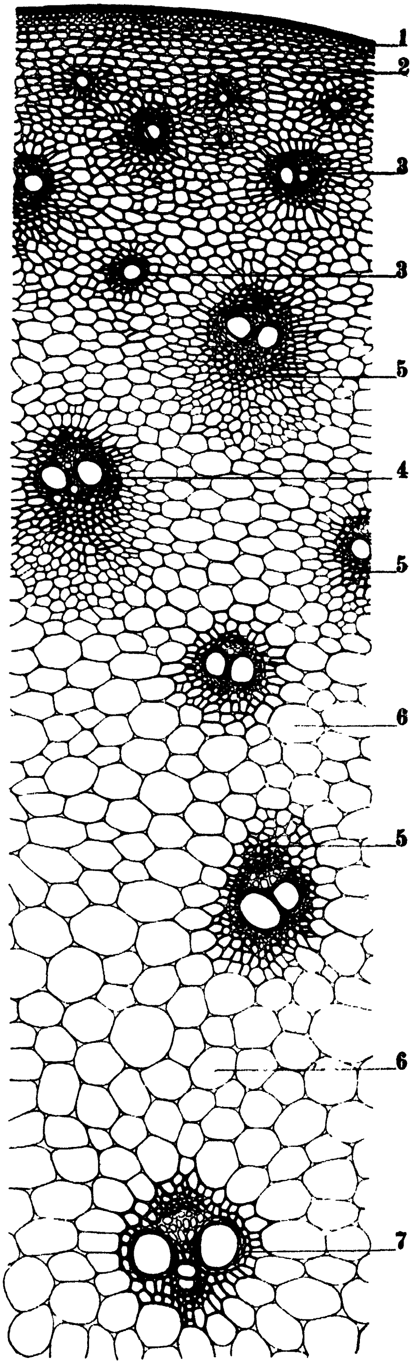
The stomata open into large air-chambers which communicate with intercellular spaces extending all through the ground tissue, providing channels along which the air may pass to practically every cell in the leaf.

Fibro-vascular bundles are very numerous in the leaf. They are of several different sizes, those which can be seen as veins on the surface of the leaf being even larger than the one shown in the center of Fig. 16. Their elements are the same as those already described for a bundle in the stem. Their arrangement is more compact, however, and the sclerenchyma is usually composed of thicker-walled cells. Each fibro-vascular bundle is surrounded by a layer of special cells of the ground tissue, known as the bundle-sheath (10). The cells in the bundle-sheath always contain a few chloroplastids. The principal chlorophyllous tissue is located directly outside of the bundle-sheath and consists of one or two layers of rather small cells. These cells are densely packed with chloroplastids, which are shown black in the figure. Chloroplastids also occur in the cells directly surrounding the air chambers.

The ground tissue supplies considerable sclerenchyma (thick-walled cells) to give strength to the leaf. This occurs mostly in the form of fibers just beneath the epidermis and opposite a vascular bundle, but isolated strands appear all through the ground tissue.

The chlorophyllous and motor cells of the ground tissue are thin-walled, and their walls are always saturated with moisture, so, as the air passes over their surfaces, carbon dioxide goes into solution in the water and is thus absorbed into the cells, while water is at the same time taken up and carried off by the moving currents of air.

In comparison to tissues of the leaf, those of the stem are relatively simple; in fact, we obtained a very good idea of these by examining sections of the stem



with the naked eye. Fig. 17 shows the structure of the stem as seen under moderate magnification. We are already familiar with the position and structure of the fibro-vascular bundles of the stem. The tegumentary tissue consists of a single layer of cells, the epidermis, with their outer walls cuticularized like those of the epidermal cells of the leaf. The cells of the ground tissue directly beneath the epidermis are very thick-walled also, and, with the epidermis, constitute what we commonly speak of as the rind. The rind is not a true tissue, and is not sharply marked off from the rest of the ground tissue. The cell walls of the ground tissue cells become gradually thinner as we progress inward from the epidermis, until they reach a thinness which is characteristic of the ground tissue throughout the greater part of its extent.

The chief functions of the tissues of the stem are to give support to the plant, to conduct water and to store up sugar. The sugar manufactured in the leaves is very promptly moved back into the stem and that which is not required for immediate consumption in the building of new protoplasm, and new tissue, is stored in the ground tissue of the stem. While sugar may be moved to some extent through the sieve-tissue, it is mostly handed on through the cell walls from cell to cell in the ground tissue.

FIG. 17. Section through the outer part of a cane stem. 1—epidermis; 2—thick-walled ground tissue cells forming the rind; 3, 4 and 7—vascular bundles of different sizes; 5—thick-walled supporting fibers; 6—thin-walled cells of the ground tissue.

The Kentucky Sanitary Privy.*

[*The privy vault in common use throughout Hawaii as a means of disposing of human wastes constitutes the greatest nuisance we have to deal with in providing better sanitation. Attempts have been made to make the ordinary privy fly-proof, none of which has worked out in practice. Disinfection at regular intervals helps out, but does not accomplish results we hope for. As a disease-breeder and means of providing for the distribution of disease-breeding germs, the privy vault has no equal.*

In order to make our plantation villages safe from the health point of view, ways and means of disposing of human excretions have had our attention and have been the cause of numerous experiments.

We are pleased to recommend for your consideration the Kentucky Sanitary Privy as described in a Bulletin issued by the State Board of Health of Kentucky in January, 1920.—*Industrial Service Bureau, H. S. P. A.*]

After years of study and painstaking experimental work, with helpful suggestions from many co-workers in this field, the State Board of Health offers this septic tank privy as the first forward step looking to the practical, effective, and economical disposal of wastes from the human body, in unsewered towns and country districts. In the various types of the tank described and illustrated in this Bulletin it will be seen that by increasing the length of the tank, and of each chamber thereof, indefinitely, and even the width and depth, where great capacity is required, it easily can be adapted to the needs of any home, school, hotel, health resort, court house, railway station, mining camp or similar place not on a line of public sewers.

In addition to the reliance which confiidently may be placed upon bacterial action for the destruction of disease germ life and the liquefying of all solid discharges, if properly constructed and cared for, and if no disinfectants are ever put in, the tank will be odorless, self-cleaning, fly-proof and will last forever. The invention is not patented; thousands of the tanks are in successful operation in this and other states and countries; in response to requests for plans and information about it, 250,000 bulletins have been sent over the country from Canada to Mexico and overseas countries.

The importance of actively and systematically extending this vitally essential feature of reform can hardly be overestimated. This movement may be forwarded by educational campaigns, direct legislation, as adopted in North Carolina, or other means, until every rural home in Kentucky enjoys its health and live-saving benefactions.

The average duration of human life in India, a retarded race in a country favored by nature, is 25 years, while in Sweden, less blessed naturally, but well

* **Bulletin of the State Board of Health of Kentucky, January, 1920.**

advanced in the observance of the laws of healthy living, the average of life is 54 years. Soper tells us within the present month that of the 1,600,000,000 people now in the world, only one per cent exist under proper living conditions. and that these fortunate few are constantly endangered by the large majority of their neighbors who do not so live. The truth of these estimates is borne out in Kentucky by the study of the sick and death rates, now collected and recorded under a rigid law, which shows that 60 per cent of the sickness and 47 per cent of the deaths occurring every year are from diseases which are distinctly and practicably preventable at far less cost than is required to care for the sick and bury the prematurely dead from them; and even more forcibly by the official records of the recent world war for the United States, which show that 34 per cent of those volunteering or chosen by selective draft were found upon exam-

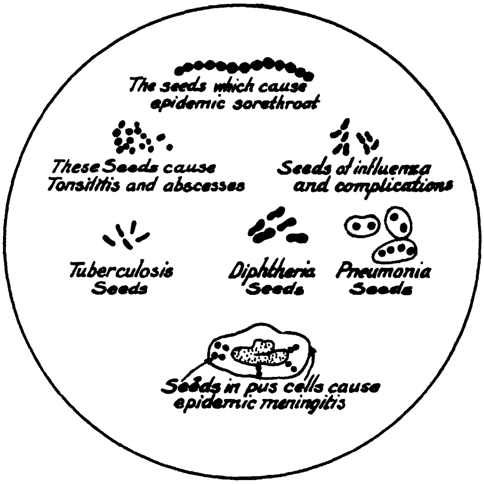


Fig. 1. Organisms causing some of the more frequent diseases of the lungs and air passages. All discharges containing them should be immediately and systematically burned or put in the tank.

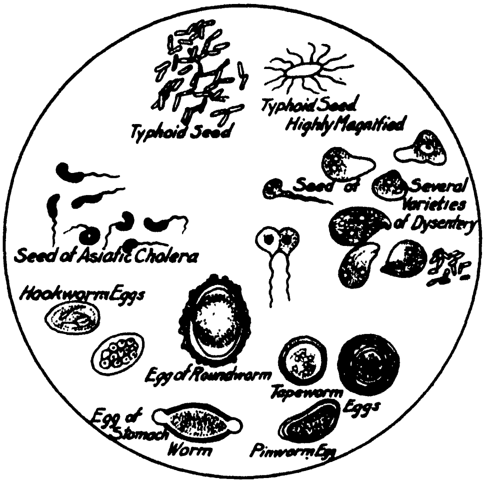


Fig. 2. Organisms causing some of the more common bowel diseases. These would be destroyed and all such diseases exterminated if everybody used a Kentucky Sanitary Privy.

ination to be as unfit for army service, as at least half of them were for the equally important duties of civil life, including, so far as the State and future generations are concerned, the paramount function of parenthood. It is hardly necessary to ask how far these physical defects and the high morbidity and mortality in Kentucky may be due to the fact that, even including sewered cities, over half the homes in this State are without a pretense of privies of any kind.

Germs peculiar to each of the communicable diseases, get into the body directly through its only portals, the mouth or nose, or are deposited in such hotbeds for their rapid and endless reproduction as are furnished by pollutions to be found around almost all homes not connected with modern sewers. The danger to all except immune persons becomes real and immediate, as shown by the 60 per cent of sickness and 47 per cent of deaths from these diseases occur- over half the homes in this State are without a pretense of privies of any kind.

In order to emphasize the importance of all this, it should be known that, except malaria and yellow fever, carried to man only by the bites of two of the

twenty-eight known varieties of mosquitoes; bubonic plague, by the bite of the rat-flea; hydrophobia, by the bites of dogs, cats, and other animals, and the venereal diseases, usually carried by immediate contact of the infected with non-infected persons, each of the communicable diseases is spread by its own peculiar germ or seed, the class causing the highest sick and death rate being excreted by those sick of them, or by carriers, through the mouth or nose, and all the balance through the bowels, except those of typhoid fever, which are also excreted

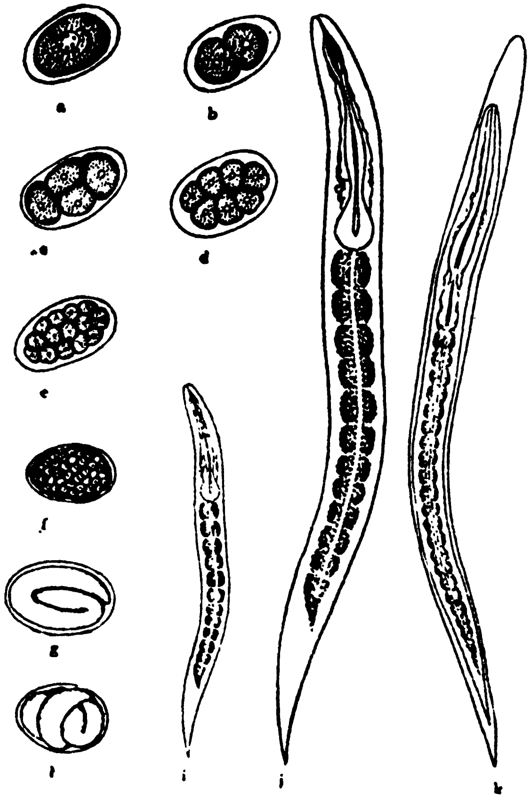


Fig. 3. Hookworm eggs (a to g) in various stages of development, found in abundance in discharges from bowels of hookworm patients, and young hookworms (i to k) ready to bore through the skin of any one who comes in contact with them. All highly magnified, since they are too small to be seen with the unaided eye. The privy destroys these, either in the egg or young hookworm stage.

through the kidneys. It is important, too, to bear in mind that the germs of each of these diseases, after its kind, although microscopic in size and with generations counted by hours and days rather than by months and years, as in the large animal and vegetable kingdoms, are as unlike in form, growth, and life history as the seed of corn is to wheat, or that of grass to clover. These have been so closely studied that trained health officials know the characteristics and

methods of spread and prevention of each of them as well as scientific farmers and orchardists do those of weeds, scale, and other pests to crops and fruit trees.

They know, for instance, that the germs of human tuberculosis, pneumonia, and all other infectious diseases, are excreted from the mouth and nose of the diseased person, and are spread by being carried to the mouth and nose of the well person. They know equally well that these diseases would be reduced to a minimum and finally exterminated if proper sanitary measures were employed, such as isolation of patients having an infectious disease, proper living conditions, etc. They know in the same way that the germs of typhoid fever and other intestinal diseases are excreted only from the bowels of the sick, or carriers of these diseases, and cause infection only by getting into the mouth or intestines of susceptible well people. If all such discharges could be immediately emptied into one of the septic tanks, these diseases would soon have only an historic interest to our people.

Essentials.

The essential principles of the privy are the tank and tile drain system, the inoculation by means of the well rotted horse manure, the carefully screened, clean, comfortable house.

The Location of the Privy.

This privy should be located as close to the house as is convenient, say not more than 10 or 15 feet from the back door, but it should be as far removed from a well or cistern as possible, to guard against accidental leaks in either structure. The privy should be placed on high ground and the drainage from it should be away from both the residence and the water supply.

Digging the Hole.

Having selected the location, the hole should be dug. For a privy of this size it should be 5 feet long, 4 feet wide, and 3 feet deep. It is best to mark out the size of the hole with stakes and a string and then dig the hole inside the string, but slightly smaller on all sides until it is nearly the required depth. Then the hole can be brought to exact size by carefully trimming the walls and bottom, making the sides smooth and exactly perpendicular, the corners square, and the bottom level. It is worth a little effort to make a neat job of the digging, since smooth walls and close measurements save cement and make the form easier to handle. If the pit is dug in sloping ground it should be dug three feet deep at the highest point and *no deeper. This is important.*

Constructing the Form.

At first sight the difficult part of the construction of a sanitary privy seems to be in making the form. In reality this is a very simple procedure. A study of Fig. 4 will show that there are only seven different sizes of parts, and if these are cut accurately to the sizes shown, there need be no trouble in putting them together. Begin by making the two sides, using A, B, C, and D, being sure that the battens are nailed on the inner faces of the sides. Then nail pieces E to the two sides so as to form the ends and baffles, putting the hole for the outlet tile

elbow in the end next to the "standing" baffle. The center of this hole must be 8 inches from the top of the form. This will bring the bottom of the outlet 2 inches below the top of the baffle.

Now nail on the four strips G, and, lastly, the two strips F. These parts, G and F, hold the top of the form in line and also make the shoulders in the concrete shown in Fig. 5, on which rest the seat riser and the boards for supporting the top.

Use six-penny nails for putting the form together, and do not clinch the ends if they should happen to come through. When done in this way there will be no difficulty in taking the form apart in order to remove it from the tank. By simply prizing off the battens "A," using ordinary care, the form may be removed

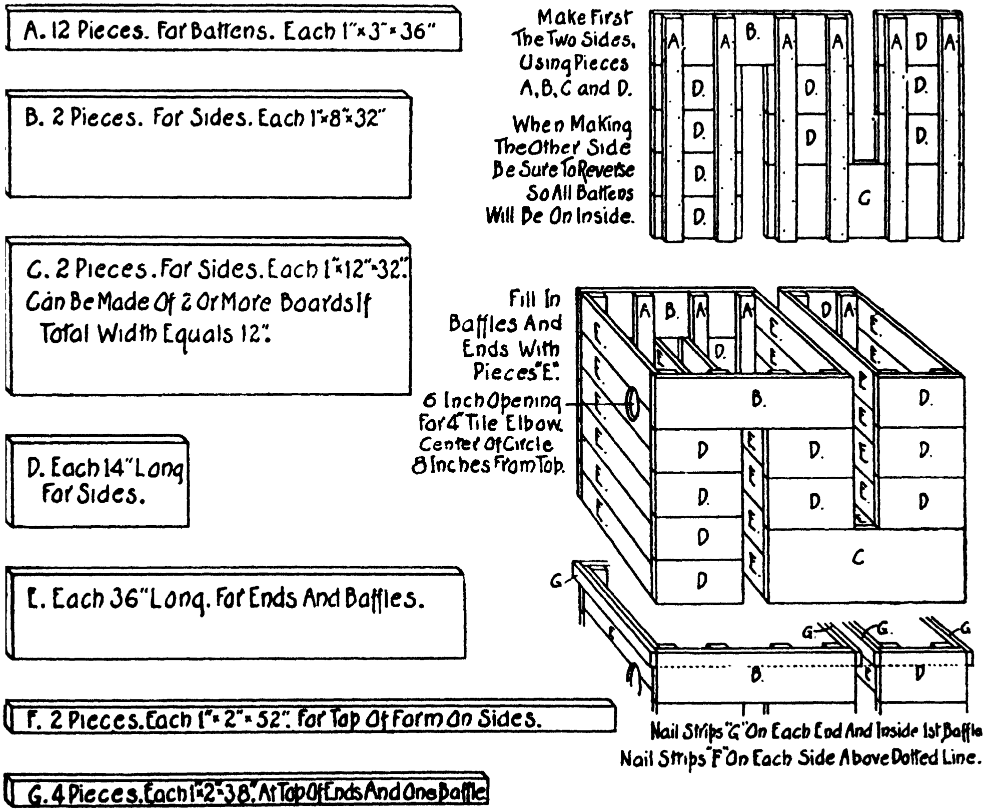


Fig. 4. Lumber for the forms for a small-sized tank. With care in fitting the parts together, as described in the context, and removing them after the concrete has well "set," the same form can be used over and over again for an entire community.

without damage and it may be used over and over again to construct other privies of this size.

The Mixing of the Concrete.

Concrete is a mixture of (a) Portland cement, (b) sand, (c) rock or gravel, and (d) water, which hardens upon standing. It varies in strength according to the proportions of the ingredients. In building a Kentucky sanitary privy

the same strength of concrete is used throughout. This is known as a 1-2-4 mixture and is composed of one sack of fresh Portland cement, two cubic feet of clean sand, and four cubic feet of broken rock or gravel. Broken limestone, in pieces never larger and preferably smaller than one inch in diameter, is best. Sand and gravel should be free from clay and other dirt or trash, such as leaves or sticks. The proportions given above should not be varied or changed. A richer mixture is more expensive and a weaker one will not be durable, or may cause the tank to leak. Before making the concrete it is best first to make a mixing board and a measuring box.

The mixing board should be about six feet square and should be tight enough to keep the liquid cement from running through, although small cracks can be stopped with sand. The measuring box should be made of four pieces of wood, besides the handles. On the inside it should be exactly two feet long, one foot wide, and one foot deep. Thus it holds exactly 2 cubic feet. This box has no bottom.

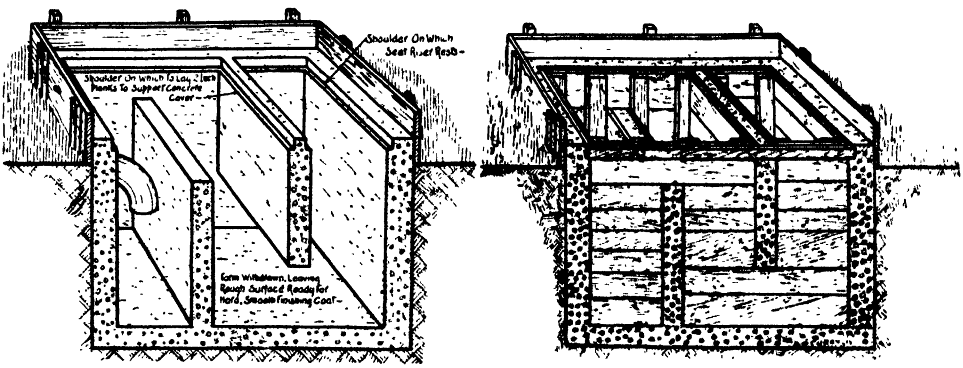


Fig. 5. Concrete poured and allowed to set before removing form.

To mix a batch of cement, set the measuring box in the center of the board and fill it level full of sand. Lift the box by the handles. The sand, 2 cubic feet, remains on the board. Set the box down again and fill twice with the clean gravel or rock, 4 cubic feet. Sprinkle over the rock and sand the contents of one sack of cement. This does not have to be measured, since a sack holds just one cubic foot of cement. Now thoroughly mix the *dry* cement and sand and rock by turning over and over on the mixing board with a shovel. After the cement and sand and rock are well mixed the water should be added, and again the whole mass should be mixed by repeatedly turning over and over with a shovel. An inexperienced person is very apt to use entirely too little water. A properly wetted batch should be so nearly a liquid mass that it will flow into place without much tamping. It should be about the consistency of rich cream or buttermilk and should easily find its level when slightly tamped or joggled with a thin plank or spade. Water is always cheap and easy to obtain and cement made without plenty of it will be hard to work and is apt to leave large crevices between the pieces of stone and cause a leak.

Do not make up a batch requiring more than one sack of cement at a time. Thus each successive batch will be fresh when placed in the form and will unite

perfectly with the preceding one and when set will be strong and durable. Be sure that the cement you buy is fresh. It should be as finely ground and as smooth as flour and entirely free from lumps and gritty masses.

Pouring in the Concrete for the Walls.

If the form and pit have been made according to the directions given above and the floor of the pit is level and smooth, it will be found when the form is in place, there will be a space of about five inches all around between the outside of the form and the walls of the pit. The top of the form will extend up above the ground about 8 inches. Use a spirit level to see that one side or end of the form is not higher than the other. Should the bottom be soft earth the form can often be made level by tapping on the high side, forcing it slightly down into the ground.

The 4-inch glazed tile elbow should now be placed in the opening made in the end of the form for that purpose, as shown in Fig. 5. Place the bell end of the tile snugly against the earthen wall and let the curved end project downward into the tank as shown in the drawings. It will be well to stop up the bell end of the elbow with a large wad of paper to prevent cement from flowing into it, but be sure to remove this wad before laying the balance of the drain.

The earth wall makes the outside form until the surface of the ground is reached, but around the outside of the hole above the ground a form should be built of four planks as shown in Fig. 5.

Now begin to pour concrete in the space for the walls, allowing it to come up evenly all around the form. As the concrete is poured it should be tamped or joggled slightly to cause it to flow into all the open spaces. By working a very thin plank or a spade up and down between the face of the concrete and the form, the larger pieces of rock will be forced back and only smooth concrete will remain in contact with the wood, and it will be found when the form is removed that this will give a smooth face to the inside of the concrete which will require very little work to finish smoothly with a trowel or brush.

Having poured the walls, the work must now be allowed to stand for twenty-four or forty-eight hours to "set," so that it will be hard and stand up when the form is removed. In the meantime the tank should be covered over to prevent too rapid drying of the exposed parts and to keep out rain and dirt.

While waiting for the tank to set you may, in order to save time, proceed to complete the tile drain.

After the concrete walls are safely set, so as to run no risk of breaking down, the inside form may be removed.

This is best done by simply prizing off battens "A." If the form has been put together with small nails this can be done with but little harm to the lumber and the form may be used over and over again to build other privies.

The form should be taken out *before the concrete is entirely dry* and then the entire inside of the tank, including the floor, must receive a smooth finishing coat made of equal parts of cement and sand, with plenty of water, and carefully applied with a brush or trowel. This finishing coat will not adhere to dry concrete, but when applied while it is moist it will adhere perfectly and render the tank completely waterproof.

Pouring the Top.

The next step is to put the "seat riser" in place. This is made of good dressed lumber, exactly to fit on the shoulder provided for that purpose over the first compartment, and should be about 21 inches high, so that, when the top is poured on, this seat riser will still project up 14 inches, which is about the right height for an adult's seat.

Over the balance of the tank place a covering of heavy planks one and one-half or two inches thick, in the shoulders left in the top of the walls for that purpose. This furnishes a support for the concrete cover while it is setting, and is not to be removed.

Now pour a layer of concrete about 2 inches thick over the entire top and around the seat riser. Then put in the reinforcing, which may consist of a piece of woven wire fencing, or iron rods, pieces of gas pipe or old buggy tires, and, on top of this, complete the pouring of the top until it has attained a thickness of five inches. While the concrete is still very soft place the four iron bolts head down in the cement about three inches from the edge and extending up two and one-half or three inches out of the concrete. The concrete should be tamped snugly up against the bolts and a large washer next to the head will anchor them still more strongly. These bolts serve to fasten the sills of the house firmly to the foundation, so that it will not blow off. The exposed surface of the top, which is to be the floor of the privy, should be finished with a rich mixture of concrete, half cement and half sand, and made perfectly smooth with a wooden float in order that it may be kept scrupulously clean.

Until the top of the tank has thoroughly set it should be well protected against injury from rain drops, too rapid drying, or other accidents. This is best done by covering it with a layer of wet tow sacks over which a layer of planks is placed. This will also prevent the concrete from cracking while seasoning.

The House.

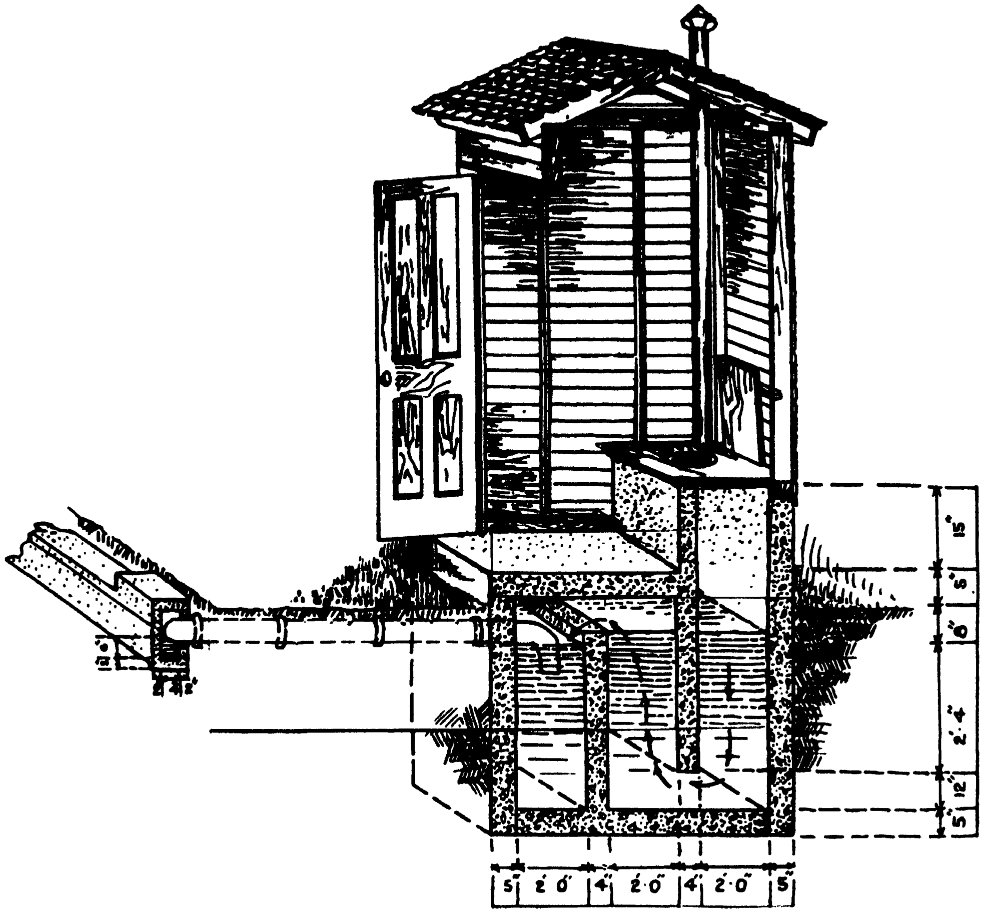
The house (Fig. 6) is a necesary part of any privy and it should be well constructed, pleasing in design, and, if possible, harmonious with its surroundings. It should have a good roof, and will be more comfortable if it is lighted and ventilated by a screened window placed high above the floor.

The Seat.

It is essential that the seat be constructed according to the design here given. As has already been shown, it must extend down into the concrete, forming a tight joint with it, and it must be provided with a well-fitted hinged cover to exclude flies and other disease-distributing insects. A block of wood nailed to the wall behind the seat will prevent it from remaining open when not in use

Operating the Privy.

See that the tank is full of water until it begins to run out into the drain tile and make sure that the manure has been put in. Provide a good quality of tissue



Vertical Section of Tank and House.

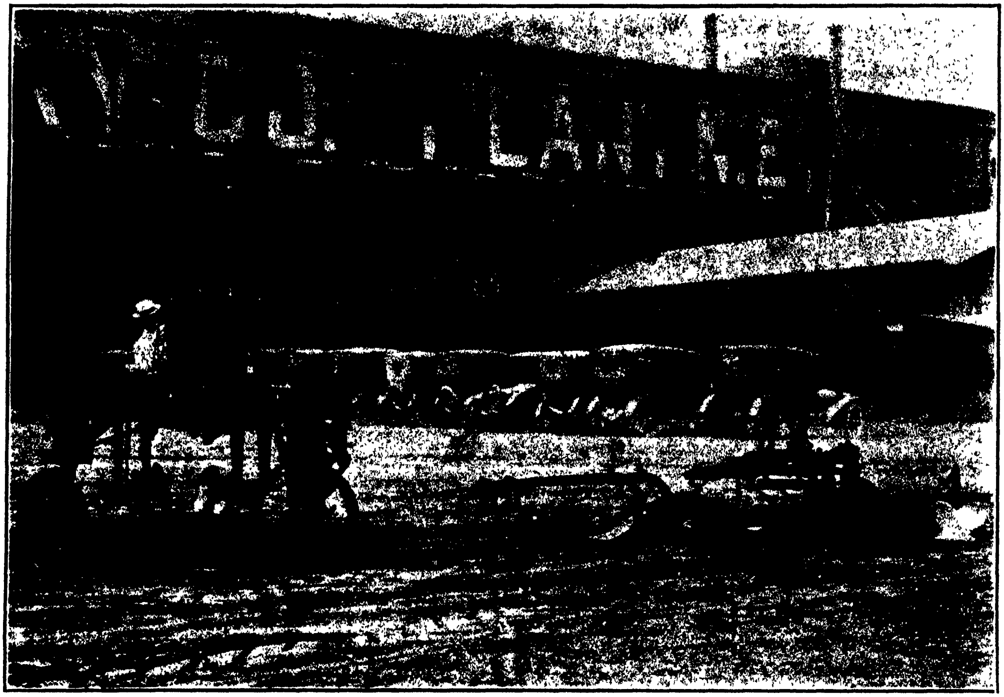
Fig. 6. A 600-gallon tank for a large family and home. It may be used for an outside privy, to receive the waste from an inside toilet and bath room, or for both purposes. By increasing the length of the tank and of each of the three chambers, indefinitely, and even the width and depth where great capacity is required, it easily can be adapted to the needs of schools, hotels, and similar public places. Properly managed, it is self-cleaning, odorless, fly-proof, and will last forever. The material for a tank of this size should not cost over $25.00.

toilet paper, since any other kind of paper will dissolve too slowly and will clog up the tank. When in constant use it will probably not be necessary to renew the supply of manure, but in case the privy is closed for a long period, as at a school during vacation, or when the home is unoccupied, it may be advisable to renew the manure when the tank is again put in operation.

A bucket of water must be poured in somewhat forcibly through each seat opening every day when the privy is being used. Not only does the privy require the addition of water, but no floating masses must be allowed to accumulate, so as to form a mat upon the surface of the water in the first compartment of the tank. Pouring water directly through each seat opening breaks up these masses

and causes them to dissolve easily. If a urinal is provided it also must be flushed in the same way each day. *If there is any odor from a properly constructed sanitary privy, it is because water is not being added every day in the proper manner and amount.*

New Implements for Sugar-Cane Culture.



This illustration shows a motor cultivator designed for the Argentine sugar districts. There are four different attachments, viz.: (1) a middle buster to be used in opening up the furrow in which to lay the seed cane; (2) a disk hiller which is to be used to cover the cane after it is planted; (3) off-barring plows for tearing down the ridges or throwing the dirt back; and (4) a reversible disk harrow attachment, with the idea of cultivating two middles at the same time.

Welded Boiler Explodes.*

At 11 a. m. on July 16, a small boiler of the firebox type exploded in a saw-mill near McMinnville, Tenn., killing the fireman and a laborer, the former instantly, and badly scalding the owner and two others. The explosion was especially violent, completely demolishing the engine and mill equipment, and occurred without warning.

A few minutes before the explosion the owner noticed about one inch of water in the glass. The safety valve was popping off, and the gage showed 12 pounds. The owner instructed the fireman, a green hand, to turn off the injector, and when the glass stood half full, he turned off the injector himself. Two or three minutes afterward the explosion occurred.

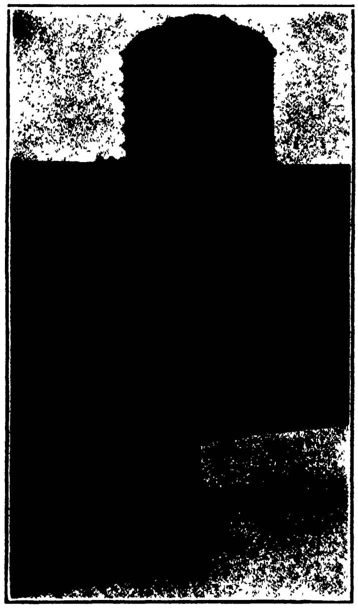


Fig. 1. Showing location of crack and corroded area.

Fig. 1 shows the type of boiler, the heavy irregular line indicating an old internal crack in the shell almost two feet long. Within the area inclosed by the dotted line the plates and staybolts showed evidence of having been badly corroded. Only four inches of this long crack was visible from the outside, and this portion was welded electrically about a year ago to prevent leakage. In welding, metal had simply been "spotted" over the crack, adding nothing to the strength of the sheet. The average thickness of the sheet over the entire length of the crack was something less than one-sixteenth inch. The condition of the sheet at this point may be seen in Fig. 2. The remainder of the metal in the boiler was in good condition, and the crown sheet showed no evidence of low water. The fusible plug was intact, although filled with shot lead.

The initial rupture apparently occurred at the point where the repair had been made by welding. The shell was torn entirely in two, and the two halves hurled one hundred feet away in opposite directions. The fracture followed the girth seam nearest the crack, but the violence of the explosion caused the shell to tear in several other places, and as part of the metal, including the steam dome, could not be found, it was impossible to trace exactly the entire course of the fracture.

This occurrence demonstrates the extreme hazard involved in operating even the smaller-sized boilers without experienced help and expert inspection,

* Power, August 10, 1920.

Fig. 2. The weld in which the metal was only spotted.
Fig. 3. Remains of front end. Fig. 4. Firebox end. Arrow indicates line of initial rupture.

and of attempting by the welding process a repair of the kind described. The owner of the plant was inclined to the belief that the initial failure could not have been at the crack, actually stating that the failure of the sheet at this point would have relieved the pressure and therefore have rendered an explosion impossible. Such statements point to the necessity of rigid state inspection laws, and of operation of boilers only by competent men. There are undoubtedly hundreds of boilers in daily use in as hazardous condition as this one was, the lives of the workmen and the safety of the equipment hanging by a very slender thread.

[W. E. S.]

The Prevention of Sugar Deterioration by the Use of Superheated Steam in Centrifugals.*

By NICHOLAS KOPELOFF.‡

The deterioration of manufactured cane sugar has been the subject of considerable investigation to which reference has already been made.[1] Following a study of the most important single group of micro-organisms, the molds, responsible for sugar deterioration, the writer prepared a chart whereby it was possible to predict the keeping quality of a sugar.[2] It remained to devise some means of eliminating the causative organisms in order to prevent sugar deterioration. Shorey[3] and others have suggested the use of superheated steam in the centrifugals, but so far as we have been able to ascertain no controlled experiments have been conducted to test out the efficiency of such an agent. Unfortunately, it was not possible to arrange for an equipment in our sugar house and mill which would permit of such a study, and it was due to Assistant Director W. G. Taggart, who devised an apparatus to be used in the laboratory centrifugal, that the present experiment was made possible.

The centrifugal used was an 11-in., 1915 model, No. 2, made by the International Instrument Company of Cambridge, Mass. The jacket had a diameter of 11 in. and a depth of 3.5 in. A larger concave trough 15.25 in. in diameter and 6.5 in. deep caught the molasses. The device used for superheated steam was simple in construction, consisting of a half-inch intake pipe with two arms (⅜ in. diameter), one inside the basket, stopping 1.5 in. from the bottom, the other between the basket and the trough. These were made of copper, sealed off at the lower end, and had a slit in the side facing the surface of the sugar. The device was securely attached by means of screws to the outside trough. An autoclave was used as a source of steam, the outlet pipe being connected by a nipple and thick rubber tubing with a 10-in. superheater (or heating spiral such as used with an Abbé refractometer), which in turn was connected with rubber tubing to the device in the centrifugal through a hole in the cover, the latter being kept closed during the course of the experiment. Fig. 1 is a diagrammatic illustration of the apparatus used.

Confectioners' crystals, which are large in size, were sterilized and coated with a blackstrap molasses which was heavily inoculated with micro-organisms such as *Aspergillus* Sydowi Bainier, *Aspergillus niger, Penicillium expansum, B. vulgatus, B. megatherium, B. mesentericus,* and all the bacterial colonies developing from 150 plates poured from Cuban raw sugar. A massecuite of medium density was prepared and the centrifugal steamed out after receiving a swabbing with alcohol containing carbolic acid.

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* The Journal of Industrial and Engineering Chemistry, September, 1920.

‡ Louisiana Sugar Experiment Station, New Orleans, La.

1 Kopeloff and Kopeloff, Louisiana Experiment Station, Bulletin 166 (1919).

2 Louisiana Experiment Station, Bulletin 170 (1920).

3 J. Soc. Chem. Ind., 17 (1898), page 555.

The procedure was then as follows: The autoclave was run up to 22 lbs. pressure or a temperature of 263° F. The massecuite was heated to 104° F. (40° C.) for about 10 min., and poured into the centrifugal basket until it formed a layer three-fourths of an inch deep. The superheater was started with a Bunsen burner (asbestos being used to protect the rubber tubing) to get it well heated before the steam was added, then the centrifugal was put in operation (attaining a maximum of 3000 r. p. m.) and the steam turned on for 3 min.

Upon stopping the steam and centrifugal the temperature of the sugar was 155° F. (68° C.). Naturally, the sugar cooled very rapidly and doubtless the heat attained while the superheated steam was being applied was considerably in excess of this figure. The sugar was washed as white if not whiter than with a jet of water such as is ordinarily used. Samples of the sugar and the molasses coming from it were taken in sterile containers for bacteriological analysis.

The same procedure was repeated with a 1.5 in. layer of massecuite previously heated to 136° F. (58° C. for about 5 min. and at about 122° F. (50° C.)

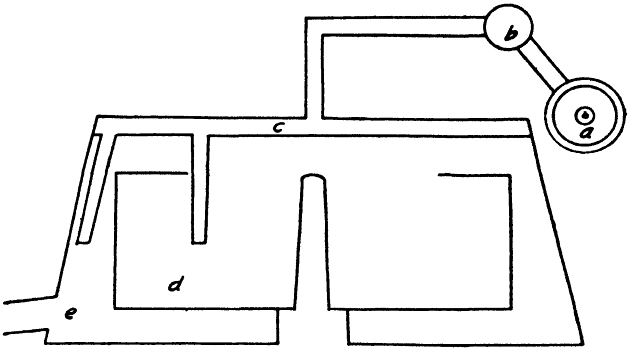

Fig. 1. Diagram of device for using superheated steam in laboratory centrifugal. a—autoclave; b—superheater; c—intake pipe with arms for delivering steam on inside and outside of basket; d—basket; e—jacket.

for 10 min. more. In this case the steam treatment was interrupted owing to a bend in the tubing which blew off one of the connections. At the end of the treatment the temperature of the sugar was 158° F. (70° C.).

The samples taken above were plated out in three dilutions on Kopeloff's agar,* incubated at 30° C., and read after 3 and 7 days. The data are presented in Table 1, in which are recorded the closely agreeing averages of quadruplicate determinations of each of the three dilutions.

TABLE 1.—EFFECT OF SUPERHEATED STEAM IN THE CENTRIFUGAL ON NUMBER OF MICRO-ORGANISMS IN SUGAR.

Treatment	Bacteria per Gram	Molds per Gram	Per Cent Reductions	
			Bacteria	Molds
Untreated, 40° C.	1,500,000	550	....	....
Steamed	8,000	10	99.47	98.28
Molasses	235,000	275	84.34	50.00
Untreated, 58° C.	200,000	110	....	....
Steamed†	14,000	10	93.00	90.91

* Loc. cit.
† Steam treatment interrupted.

It will readily be seen that in the first instance the untreated massecuite had 1,500,000 bacteria and 550 molds per gram, while the treatment with superheated steam resulted in reducing the content to 8000 bacteria and 10 molds per gram, a diminution of 99.47 per cent of the bacteria and 98.28 per cent of the molds, respectively.

This means an efficiency in the decimation of the micro-organisms which is remarkable and the significance of which will be discussed in detail presently.

The molasses from this sugar had 235,000 bacteria and 275 molds per gram, a reduction in 84.34 per cent of the bacteria and 50 per cent of the molds.

This is again proof of the sterilizing effect of superheated steam, since it may be inferred that the heat attained for the short time necessary to wash the molasses from the sugar was sufficient to kill more than three-fourths of the bacteria and one-half the molds. Furthermore, this is of practical value from the standpoint of the keeping quality of the molasses. We have previously referred to the unsanitary conditions under which most molasses is kept, frequently in tanks literally covered with a mat of mold mycelium. It is logical to suppose that where the original mass infection may be so materially reduced, the keeping quality of such a product may be greatly enhanced. Moreover, we have here an advantageous substitute for wash water which is frequently of questionable character and often responsible for a heavy inoculation with micro-organisms.

Moreover, these data indicate that by far the larger proportion of micro-organisms contained in the massecuite leave the centrifugal in the wash. Therefore, when it is the practice to separate the molasses and the wash, a less contaminated molasses is procured with undoubtedly improved keeping quality.

In this connection a digression may be permitted, which may be worthy of trial: namely, where molasses is not fermented and it is desired to keep it for some time, we would suggest the use of a thin layer of oil on the surface. This would prevent a mass infection at that vulnerable point and could be easily removed. The oil in this way need not affect either the quality, odor, or taste of the molasses. On the other hand, where mold growth already covers the surface it might be advisable to spray with toluene, which is cheap enough to be economical, germicidal enough to kill the molds, and volatile enough to be removed within a few days by exposure to the air. Since the pressure of time does not permit of the opportunity of developing these suggestions in the sugar mill, they are advanced for what they may be worth.

Returning to the latter half of Table 1, it will be seen that where the massecuite was heated to 122° F. (50° C.) the untreated sample contains only about one-eighth the number of bacteria and one-fifth the number of molds present in the massecuite heated to 104° F. (40° C.). This means that a partial sterilization has already been effected. The treatment with superheated steam was interrupted and the final results show that 93 per cent of the bacteria and 91 per cent of the molds were eliminated. It was to be expected that these figures would be somewhat below those obtained in the first instance, since the partial sterilization referred to probably eliminated the least resistant organisms and left a flora relatively more resistant than the one originally present. The interruption of the steam treatment must have been responsible for some loss in efficiency. Finally, the difference may be ascribed to the fact that the layer of sugar in this instance was twice as thick as that used in the first instance. It is to be expected

that four important factors would be operating in such an experiment, viz., temperature of steam, duration of application, thickness of layer of massecuite, and speed of centrifugal.

From the data set forth it is evident that the use of superheated steam under the conditions of the experiment was instrumental in almost entirely eliminating the micro-organisms present, the important consideration being that this was accomplished without increasing the moisture content of the sugar perceptibly, as in washing with water. As a matter of fact, under mill conditions it might be anticipated that even better results might be obtained where higher temperatures might be so readily available. The procedure has the merits of—

(1) Simplicity in construction and operation.

(2) Economy in equipment, installation, and operation.

(3) Efficiency under all conditions.

(4) Yielding a cleaner wash.

In working out a chart for predicting the keeping quality of sugar it was shown that two factors, moisture ratio and degree of infection,[1] operated simultaneously. It is obvious, therefore, that such a striking reduction in mass infection can be effected by the use of superheated steam in the centrifugals that the keeping quality may be greatly enhanced even where the moisture is somewhat more than it should be. For example, a sugar having a moisture ratio of 0.08 will deteriorate when 10,000 to 100,000 mold spores per gram are present. A reduction of 98 per cent, however, bringing the content down to about 1000 spores per gram, would make this sugar safe even though the moisture ratio increased to as much as 0.14 to 0.16.

Thus it may be said that in the investigations on sugar deterioration carried forward in this laboratory, the study of the micro-organisms and their activities, which made possible the prediction of the keeping quality of sugars, has found its logical completion in the development of an adequate means for eliminating the micro-organisms and consequently preventing sugar deterioration. However, it must be emphasized again that the sugar must be properly handled under sanitary conditions with a minimum possibility of absorbing moisture in order to ensure its safe keeping, since, under optimum conditions, the micro-organisms soon propagate rapidly enough to become detrimental.

Summary.

1. A simple, economical, and efficient method has been developed for employing superheated steam in laboratory centrifugals.

2. By means of this treatment the bacterial content of sugar has been reduced 93 to 99.5 per cent, and the number of mold spores has been reduced 92 to 98 per cent. The micro-organisms in molasses are reduced similarly to a lesser extent.

3. This elimination of micro-organisms improves the keeping quality of the sugar as well as the molasses.

4. With superheated steam treatment, the practice of separating molasses and wash results in a considerable reduction of micro-organisms in molasses, with consequent improvement in its keeping quality.

[W. R. M.]

[1] Loc. cit.

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